This is a reproduction of a library book that was digitized by Google as part of an ongoing effort to preserve the information in books and make it universally accessible.

Google™ books

https://books.google.com

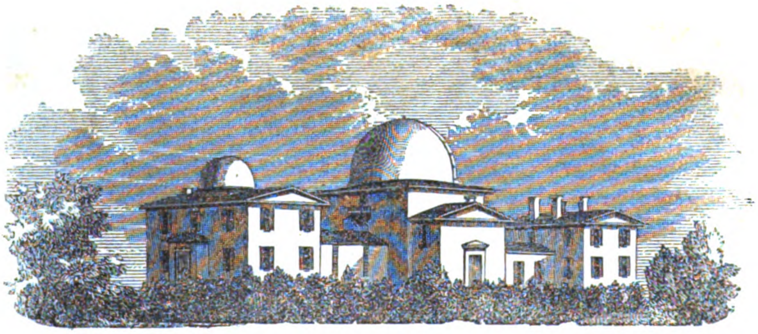
# ANNALS

OF THE

# ASTRONOMICAL OBSERVATORY OF HARVARD COLLEGE.

## VOL. I.—PART I.

PRINTED FROM FUNDS RESULTING FROM THE WILL OF
JOSIAH QUINCY, JUN.,
WHO DIED IN APRIL, 1775,
LEAVING A NAME INSEPARABLY CONNECTED WITH THE HISTORY OF THE AMERICAN REVOLUTION.



CAMBRIDGE:
METCALF AND COMPANY,
PRINTERS TO THE UNIVERSITY.
1856.

43 - 9.

BIBLIOTHECA
REGIA
MONACENSIS

# HISTORY AND DESCRIPTION

OF THE

# ASTRONOMICAL OBSERVATORY OF HARVARD COLLEGE.

BY

WILLIAM CRANCH BOND, A.M.,
DIRECTOR OF THE OBSERVATORY,
FELLOW OF THE AMERICAN ACADEMY OF ARTS AND SCIENCES, MEMBER OF THE AMERICAN PHILOSOPHICAL SOCIETY OF PHILADELPHIA, AND OF THE NATIONAL INSTITUTE AT WASHINGTON, ASSOCIATE OF THE ROYAL ASTRONOMICAL SOCIETY OF LONDON, CORRESPONDING MEMBER OF THE INSTITUTE OF FRANCE, THE PHILOMATHIC SOCIETY OF PARIS, AND THE SOCIETY OF NATURAL SCIENCES AT CHERBOURG, ETC., ETC.

---

CAMBRIDGE:
METCALF AND COMPANY,
PRINTERS TO THE UNIVERSITY.
1856.

BIBLIOTHECA
REGIA
MONACENSIS

# TABLE OF CONTENTS.

## PART I.

PAGE
PRELIMINARY PROCEEDINGS . . . . . . . . . . . . . . . . . . . i
DESCRIPTION OF THE DANA-HOUSE OBSERVATORY . . . . . . . . . . . vi
HISTORICAL SKETCH AND DESCRIPTION OF THE OBSERVATORY OF HARVARD COLLEGE . xiv
DESCRIPTION OF THE INSTRUMENTS . . . . . . . . . . . . . . . . xxxi
STATUTES OF THE OBSERVATORY . . . . . . . . . . . . . . . . . lix
REGULATIONS FOR PUBLISHING THE ANNALS OF THE OBSERVATORY . . . . . . lxii
NAMES OF CONTRIBUTORS TO THE OBSERVATORY IN THE YEARS 1839, 1843, 1846, 1847, 1848, 1851, AND 1855 . . . . . . . . . . . . . . . . . . . lxiii
REPORT OF THE COMMITTEE APPOINTED BY THE OVERSEERS OF THE UNIVERSITY AT CAMBRIDGE TO EXAMINE THE OBSERVATORY, FOR THE ACADEMIC YEAR 1845-46, WITH THE ACCOMPANYING DOCUMENTS . . . . . . . . . . . . . . . . lxvii
REPORT FOR 1846-47 . . . . . . . . . . . . . . . . . . . cxiii
REPORT FOR 1847-48 . . . . . . . . . . . . . . . . . . . cxxii
REPORT FOR 1848-49 . . . . . . . . . . . . . . . . . . . cxxxii
REPORT FOR 1849-50 . . . . . . . . . . . . . . . . . . . cxl
REPORT FOR 1850-51 . . . . . . . . . . . . . . . . . . . cli
REPORT FOR 1851-52 . . . . . . . . . . . . . . . . . . . clx
REPORT FOR 1852-53 . . . . . . . . . . . . . . . . . . . clxviii
REPORT FOR 1853-54 . . . . . . . . . . . . . . . . . . . clxxiv
REPORT FOR 1854-55 . . . . . . . . . . . . . . . . . . . clxxxiii

## PART II.

INTRODUCTION TO HARVARD ZONE OBSERVATIONS . . . . . . . . . . . . iii
STANDARD CATALOGUE . . . . . . . . . . . . . . . . . . . lxiii
HARVARD ZONES, 1852-53 . . . . . . . . . . . . . . . . . . 1
TABLE OF PRECESSION IN RIGHT ASCENSION . . . . . . . . . . . . 312
TABLE OF PRECESSION IN DECLINATION, 1853.0 . . . . . . . . . . . 313
INDEX TO ZONES . . . . . . . . . . . . . . . . . . . . 316

# HISTORY AND DESCRIPTION

OF

# THE OBSERVATORY.

---

## SECTION I. *Preliminary Proceedings.*

It has been thought proper to introduce the first volume of the "Annals of the Observatory of Harvard College" by a brief sketch of the earlier efforts which resulted in the establishment of this Observatory, together with an outline of its progress and development to the present time.

Particular details respecting the astronomical observations and discussions of Winthrop, Williams, and other Professors of Harvard, belong rather to the general history of the College, than to that of the present Observatory. There is, however, sufficient evidence of the interest taken by the community in these pursuits, at that early day, to lead us to suppose that such an accession to the College would even then have been very acceptable, and was doubtless often contemplated, in the hopeful spirit of the times, as a probable future event. We may mention especially the readiness with which the "Province sloop" was fitted out, in the year 1761, at the public expense, to convey Professor Winthrop, with his instruments and party, to Newfoundland, for the purpose of making observations on the transit of Venus over the disc of the sun.

Again, in 1780, "although involved in all the calamities and distresses of a severe war, the government discovered all the attention and readiness to promote the cause of science which could have been expected in the most peaceable times, and passed a resolve directing the Board of War to fit out the 'Lincoln galley,' to convey Professor Williams, with his instruments and party, consisting of Mr. Stephen Sewall, Professor of the Oriental Languages, James Winthrop, Esq., Librarian, Fortescue Vernon, A. B., and Messrs. Atkinson, Davis, Hall, Dawson, Rensselaer, and King, students in the University, to Penobscot, for the purpose of observing an eclipse of the sun, where, by calculation, it was expected it would be total." These, together with many similar instances, might be adduced in evidence of the zeal with which, to the extent of their ability, the people of New England, in early times, were disposed to encourage and aid the advancement of scientific inquiry.

The war above referred to was succeeded by a period of general depression. The struggle at that time was for existence as a nation. It would, therefore, be unreasonable to expect that men whose mental and bodily energies were tasked to the utmost in establishing a new and untried form of government, amid the sorest deprivations, could devote much of their time and attention to a pursuit which has been considered as eminently appertaining to a condition of peace, and to an advanced stage of national prosperity.

With the return of peace and the establishment of a well-ordered frame of government, the interests of science were not overlooked. As early as the year 1805, we find Mr. John Lowell, at that time residing in Paris, consulting with the celebrated French astronomer, Delambre, on the subject of Astronomical Observatories, and procuring from him written instructions in regard to suitable buildings and instruments. The information thus gathered was transmitted to Mr. Webber, at that time Hollis Professor of Mathematics and Natural Philosophy in Harvard College, from which we conclude that the purpose of erecting an Observatory was then under serious consideration by the friends of the College.

It does not appear, however, that any official action was taken upon the subject at that time. It was ten years later that the Corporation adopted active measures for the promotion of this object, when, at a meeting of the President and Fellows, held May 10th, 1815, — present, the President (Dr. Kirkland), Dr. Lathrop, Hon. Christopher Gore, Judge Davis, Hon. John Lowell, Judge Phillips, — it was "*Voted*, That the President, Treasurer, and Mr. Lowell, with Professor Farrar and Mr. Bowditch, be a committee to consider upon the subject of an Observatory, and report to the Corporation their opinion upon the most eligible plan for the same, and the site."

This was probably the first corporate act within the United States having for its object the establishment of an Astronomical Observatory. A sub-committee, consisting of Professor Farrar and Dr. Bowditch, was afterwards appointed to attend especially to the subject. From the chairman of this committee, the present Director of the Observatory, then about visiting Europe, received the following letter of instructions: —

"Cambridge, June 23, 1815.

"Mr. William C. Bond: —

"Dear Sir, — Please to attend particularly to the following points, in your visit to the Observatory at Greenwich, viz.: —

"The extent and clearness from objects of the horizon. The number of degrees of zenith distance which it commands all around, and particularly to the North and South. The size and form of the piers that support the instruments, their depth below the surface of the ground, and elevation above. The kind of soil on which they stand. The magnitude and kind of stone of which they are made, and how put together, whether with mortar or not. What are the dimensions of the meridian telescope or transit-instrument, how supported, and how got at in all positions. What the width of the openings in the wall and roof; how secured from the weather. The circular instrument lately made by Troughton, its form, size, and appendages, and everything relating to the manner of its attachment to its support, the dimensions of the openings provided for it, and the manner in which they are opened and closed.

"The telescopes for observing eclipses, &c., their number, kind, and size, and mounting. The form and construction of the turning roofs. The clocks, their number, kinds, supports, and situations with respect to the instruments to which they belong respectively. The same things to be attended to at Richmond and at Slough.

"Also, inquire of Troughton the price of an eight-foot transit-instrument of the best construction for an Observatory, and the price of an eight-foot circular instrument of the kind lately made for the Observatory at Greenwich, and how soon these two instruments can be completed upon being ordered. The prices of the best clocks for Observatories, and how soon one can be made, and the price of a heliostatic movement for a telescope.

"I would observe further, that, with regard to the sort of information which we wish you to bring with you, in order to answer our purpose, it must be such as to enable you or some other person to superintend and direct in the erection of an Observatory.

"The construction of those parts which you are requested to examine and take an account of, — namely, the piers for the instruments, their attachment, the form of the roofs or coverings, and, in short, whatever is peculiar to the building as an Observatory, — will require special attention. You will be able to judge, therefore, for yourself, when it will be necessary to take plans and sketches, and when a mere statement of the form and dimensions will be sufficient.

"Yours, with much regard,

"John Farrar."

With these instructions to guide his inquiries, and some letters of introduction to facilitate his admission to the principal Observatories in England, Mr. Bond was enabled to make the following year a full report to the committee respecting the points adverted to in his instructions. During his visits to the Royal Observatory at Greenwich, each room, pier, and instrument was submitted to measurement, a ground-plan was traced, designating the positions of the different instruments and clocks, with sectional views of the piers for supporting the instruments, and showing the construction of the piers so far as they could be seen or measured. A description of the foundations was obtained from Mr. Edward Troughton, and from Dr. Pond's principal assistant, Mr. Taylor. Plans were also drawn of the Observatories of Glasgow, Edinburgh, Highbury, Milford-Haven, and others, all which were transmitted to the committee.

From the Astronomer Royal, Dr. Pond, he received every attention which might tend to aid the purpose of the committee, in gathering such information as could not at that time be obtained from books. Full permission was granted him to visit the Observatory at Greenwich, whenever he wished to do so, and to stay as long as he wished. The same unlimited permission was also given to him by Mr. Groombridge, the owner of the Observatory on Black-Heath, and also by John Bentley, Esq., proprietor of a private Observatory at Highbury, and by several others. The pleasant reminiscence of a visit to Slough, the residence of Sir William Herschel, and the home of the first great Reflector, is gratefully and indelibly impressed upon his memory.

From Edward Troughton, Dr. Firminger, late first assistant to Dr. Maskelyne, the former Astronomer Royal, and from Dr. Evans, head-master of Christ's Hospital School, he received much valuable information in regard to the instruments and buildings best adapted to the intended situation and purposes, the forms and composition of piers, the manner of mounting the instruments, methods of observing, security of the instruments against the ill effects of atmospheric changes, convenience of manipulation, and everything tending to produce the most accurate results.

Upon his return home, a model dome was constructed, under his supervision, on the same plan as the one now protecting the great Equatorial. In the mean while, the committee had obtained models from Germany, and general information regarding the Observatories on the Continent.

Subsequently, on discussing the mass of information which had been collected, it was found that the amount of funds required for erecting the necessary buildings, for piers, and rotatory domes, for the purchase of instruments of the first class, — and no other were ever contemplated, — for the establishment of a fund for the support of an observer or observers, for defraying the current expenditures of the establishment after it had been put in operation, and for publishing the results of observations, far exceeded the estimates which had previously been made. An appeal to some of the more wealthy friends of the design proved that the time had not yet arrived when the project could be prudently or conveniently carried forward.

In regard to subsequent proceedings, the following extracts from President Quincy's "History of Harvard University" will serve to show, that, although the purpose was at that time necessarily suspended, it was not abandoned.

After referring to the previous efforts of the friends of the College to found an Observatory, President Quincy goes on to say: —

"The design was revived in 1822, and the same committee examined positions in the vicinity of the College, for the purpose of selecting the most suitable for an Observatory."

"A report was made very favorable to a position in that vicinity, on land owned by Edmund Dana, and authority was given to purchase two acres and a half for that purpose. The negotiation, however, failed, and further proceedings were postponed."

"In October, 1823, John Quincy Adams, then Secretary of State of the United States, addressed a letter to a member of the Corporation, urging that a building should be erected without waiting for instruments from Europe, and recommending that the site nearest the College should be selected, even should it occasion some additional expense; proximity to the College being, in his judgment, important to the health and comfort of the Professor and the students, as the night and the winter are the time and the season specially adapted to astronomical observations. Mr. Adams strongly recommended a subscription to be opened for the purpose, and, upon condition that the requisite sum should be raised in two years, authorized a thousand dollars to be put down on his account, but requesting his name to be concealed."

About this time, an address to the public was prepared and published, and a subscription opened, but the result proved insufficient.

A period of fifteen years now intervened without any marked endeavor to revive the subject; disappointment appeared to have followed every effort which was made for the accomplishment of this object, yet it now plainly appears that the means whereby it was ultimately to be attained were silently accumulating, and that the Observatory would not have been established on so broad a basis had the earlier designs of its friends met with immediate success.

For the proceedings which resulted in the occupation of the "Dana House" as an Astronomical Observatory, reference is again made to President Quincy's History of Harvard University.

"In 1839, the Corporation were informed that Mr. William Cranch Bond was engaged, under an appointment and contract with the government of the United States, with a well-adapted apparatus, in a series of astronomical and meteorological observations in connection with those which should be made by the officers of the Exploring Expedition to the South Seas, commenced in 1838, under the command of Captain Charles Wilkes, and by the authority of Congress, for the determination of longitudes, and other scientific purposes, — made arrangements with Mr. Bond, with the consent of the government of the United States, for the transfer of his whole apparatus to Cambridge, appointing him Astronomical Observer to the University, and took measures to raise by subscription a sufficient sum to erect such buildings as were immediately required." *

In the same year the house and grounds known as the Dana Estate, which, in the mean while, had passed into the possession of the College, were appropriated to the uses of an Observatory, and during the autumn of 1839, the buildings requisite for the protection, and the piers for the support, of the instruments, were constructed, and the series of observations which had been carried on for some years by Mr. Bond at his former residence in Dorchester were continued almost without interruption in Cambridge, the last Dorchester observation having been made on the 25th, and the first Cambridge transit on the 31st of December, 1839.

## SECTION II. *Description of the First Observatory.*

THE Dana place, which was now to be temporarily occupied for the purposes of an Astronomical Observatory, was a portion of the same estate which had been examined and approved by the committee of the Corporation in 1822. Since that time, however, unfavorable changes had taken place in the neighborhood, by the laying out of new streets and the erection of buildings; not merely interrupting the horizon in every direction, but extending to an altitude of thirty degrees. In the direction of the meridian it was found necessary to purchase the privilege of *tunnelling* a neighboring building, in order to procure a sight of the meridian mark, while the proximity of the main street prevented the substitution of a collimating telescope. Yet, upon the whole, it was the best situation available in the immediate vicinity of the College.

The members of the American Academy of Arts and Sciences had always evinced a friendly interest in the project of an Observatory, and, now that one was established, were active to provide the means for a more reliable, as well as a more extended, system of magnetical and meteorological observations. At a meeting of the Academy, held in Boston, April 22d, 1840, it was

"*Voted*, That a sum, not exceeding one thousand dollars, be appropriated, from the

---

* A list of the names of the contributors may be found in the Appendix.

Rumford Fund, to the purchase of the requisite instruments for making magnetic and meteorological observations, under the direction of a committee of the Academy, and in conjunction with the observations directed by the Corporation of Harvard College.

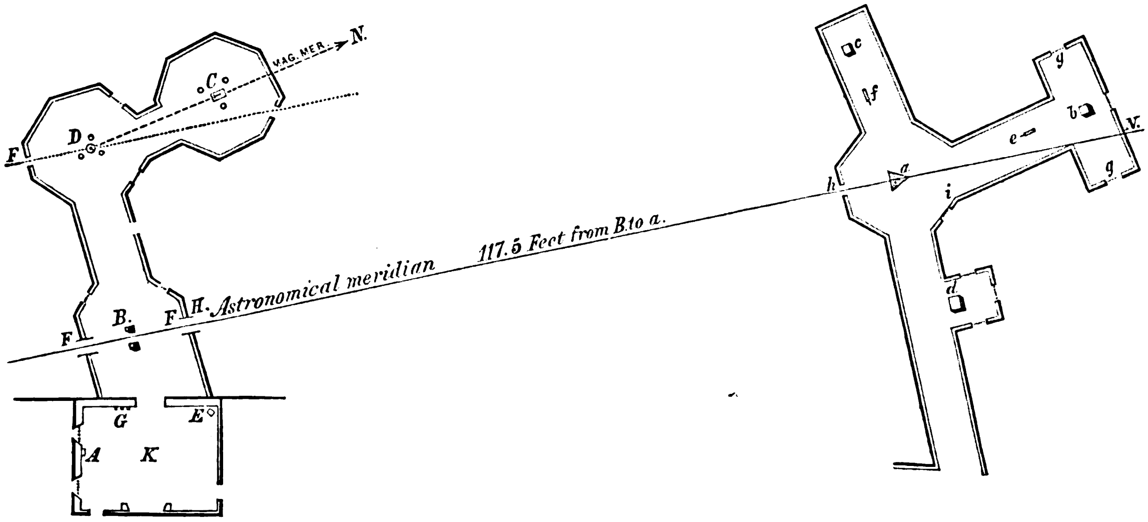
"*Voted*, That the President, Professor Treadwell, Mr. W. C. Bond, Professor Lovering, and Mr. J. H. Abbot, be a committee for the purpose of carrying into effect the objects contemplated in the foregoing vote, and the report accompanying the same; and that they be, and hereby are, authorized to draw upon the Treasurer of the Academy for a sum not exceeding one thousand dollars."

The means for purchasing the class of instruments required for the purposes alluded to having been thus liberally supplied, they were immediately ordered from the same makers who were engaged in manufacturing sets for the magnetic observatories established by authority of the British government. Meanwhile a suitable plan for the location of all the instruments, including those furnished by the Academy for the observation of the elements of terrestrial magnetism, had been determined upon.

The Dana House was a large and substantial building, situated on the southeast corner of the College grounds, having Harvard Street on the south, and Quincy Street on the east. As it was thought possible that so substantial a building might be sufficiently firm to support steadily a telescope of some power, a cupola, with a turning roof moving on iron rollers, was erected on the top of the house, under the supervision of Professor Treadwell, within which the large Reflector belonging to the College, made by Short, of London, was mounted on a platform supported by the frame of the house.

The annexed engraving represents a ground-plan of the Observatory buildings.

Fig. 1. Fig. 2.



The transit-room, and the room intended for the Gauss magnetic apparatus, adjoined the western side of the dwelling-house. The mode of entrance was convenient, and the substrata of this position proved to be well adapted to the steady support of the instruments.

The only room in the house which it was thought proper to devote exclusively to the observers is that marked *K* (Fig. 1) in the plate. The astronomical clock was placed in the northwest corner of this room, at *E*. A sidereal chronometer was preferred for use at the transit-instrument, and the relative connection between the clock and the chronometer ascertained by frequent comparison. The principal objection to placing the sidereal clock in the transit-room was the great and sudden change of temperature to which, in that case, it would, in our variable climate, have been frequently exposed. There was believed to be yet another advantage to be derived from the use of the chronometer; namely, a reduction in the amount of discrepancies between two observers arising from personal differences in their habits of observing, it having appeared, from experiments made by the two methods, that there was greater consistency among the observations while using the half-second beat of a box chronometer, than there was when the full-second beat of the clock was adopted for subdivision; the limits of error were diminished in the former case.

The standard barometer made by Newman, No. 57, was secured to the south wall, at *A*. There were, besides this, three other barometers, which were used occasionally. Two of them, which were placed at *G*, were made by W. and S. Jones of London, and were of little value; the other, of the mountain construction, was originally made by Cary of London, for the exploration of the Himalaya range of mountains. The lower surface of the quicksilver in this instrument was adjustable to a fixed zero, by contact with a glass cap, and as the connection between this cap and the scale was of brass, the temperature correction was the same as for the standard; but on account of its tube being only about two tenths of an inch in diameter, it was found necessary to refer it for correction to the standard by Newman, whenever precision was required.

The transit-instrument, made by Troughton and Simms, has an object-glass of two inches and three quarters in diameter, and forty-six inches focus; it is furnished with a micrometer, and a position-circle reading by two verniers to 10″. The piers for its support were situated at *B*. For the foundation, a large block of granite, six feet by four, was embedded in the substratum of gravel, about five feet below the surface. The upper surface of this stone was hammered smooth, and carefully levelled. The stone pillars were each of them nine feet and a half in height, and rested upon this foundation-stone by three bearings; they were enlarged at the base as much as the length of the axis of the transit would permit, consistently with the required vertical position of the interior faces of the piers.

When this instrument had been adjusted to the meridian, a stone tower was erected, at a distance of twelve miles south of the Observatory, on the western declivity of the Great Blue Hill in Milton, for the purpose of supporting a meridian mark, to be used in verifying the collimation and azimuthal corrections of the transit. This tower was built of solid masonry, thirteen feet in diameter at the base, seventeen feet high above the foundation, and nine feet in diameter at the top, in form the frustum of a cone. On this a meridian mark, of an open lozenge form, seven feet high, was firmly secured. When viewed from the Observatory, this mark presented a distinct, open figure against the sky, susceptible of nice bisection by the micrometer spider-line of the transit-instrument, affording, as occasion required, the means of ascertaining the amount and direction of the deviation in azimuth caused by the settling, or the unequal expansion or contraction of the granite piers when subjected to sudden and excessive changes of temperature.

The position of the transit was connected with the Trigonometrical Survey of the State of Massachusetts, by Simeon Borden, Esq., the Superintendent of that work, during his operations in the vicinity, and the distance between it and the mark on the Blue Hill was found to be 58,520 feet.

The terminations of this line were well marked, and may be easily recovered. A hole was drilled in the foundation stone, directly beneath the centre of the transit-instrument, which constitutes the northern terminus of this line, and the centre of the tower on Blue Hill forms the southern.

As a further security, an intermediate mark was taken on a brick house, situated about one mile distant; this afforded at times, when the condition of the atmosphere rendered the more distant and accurate mark unavailable, a ready point of reference whereby to test, approximately, the adopted azimuth and collimation errors.

In the octangular rooms *D*, *C*, west of the transit-room, which were connected with it by a covered passage-way, a "Gauss" magnetometer was mounted at *C*, for the observation of magnetic perturbations in declination. The line *F D* shows the direction of the astronomical meridian. At *C* was a well-closed wooden box, protecting a bar-magnet fourteen inches in length. This bar was suspended by its centre stirrup from a torsion-circle fixed upon the top of a strong wooden tripod, formed of three cedar posts firmly secured together at the top. The magnet was suspended from the torsion-circle by means of a silvered copper wire, five feet six inches long, which was guarded by a glass tube. To the magnet was attached an upright plane mirror, *C*. A plate of parallel glass was inserted in the south end of the box, for the purpose of admitting the rays of light reflected from a divided and numbered scale placed opposite to the mirror at *D*, to pass into the box and to be reflected back again, but at a small vertical angle, by the mirror *C*, attached to the bar-magnet, into the tube of the telescope of an altitude and azimuth instrument placed at *D*, on an insulated wooden pier, to which pier the scale was also attached. At night the scale was strongly illuminated by lamps placed in the foci of two parabolic reflectors.

By this arrangement of the apparatus, the slightest horizontal movement of the freely suspended magnet, *C*, could be immediately detected by an observer looking through the telescope *D*, and, by referring the reflected image of the scale-divisions to the fixed vertical wire in the focus of the telescope, the amount of horizontal movement very accurately determined, the zero of the scale and the value of the divisions having been previously ascertained. The direction of the astronomical meridian was derived from star observations, suitable openings in the roof and sides of the building — admitting of the observation of the pole star both above and below the pole, and also of stars to the southward of the zenith — having been provided for that purpose. Subsequently, a mark on "Gore Hall" was adopted for occasional reference; its azimuthal angle with the meridian, as seen from the point *D*, having been obtained from the star observations above alluded to.

In addition to the instruments already mentioned, the Observatory was supplied with a five-foot reflecting telescope by Short, two forty-six-inch refracting telescopes, a magnetic-dip circle of Gambey, two standard thermometers, and a rain-gauge, together with the Lloyd apparatus, which will be described hereafter.

The building, (Fig. 2,) which was situated one hundred and twenty feet north of the transit-room, and was entered by a covered way from the north side of the dwelling-house, or from the garden by a sash-window at the front, was planned expressly for the proper accommodation of the Lloyd magnetic apparatus, which had been procured through the appropriation of the American Academy.

Within this building, in the construction of which the introduction of iron fastenings was strictly forbidden, zinc, copper, or wood being substituted, there was placed, at the distance of one hundred and seventeen feet directly north of the principal transit-instrument, a red-sandstone pier, *a*. Upon this pier a "variation-transit," made by Troughton and Simms, was mounted. The axis of the telescope of this instrument was reversible in its Y's, and the azimuthal circle read by three verniers to ten seconds. Its position in regard to the principal meridian instrument was such as to render the latter available as a collimator, and also, the line of sight passing a little below it, to permit of a meridian adjustment being made by the mark on the Blue Hill, whereby the small transit could be made, in its turn, to answer the purpose of a north collimator to the principal one.

The Lloyd apparatus consisted of three "magnetometers," intended for the nice observation of the three components of terrestrial magnetism. They were arranged as follows.

The *Declination* magnetometer was placed at *b*, and its reading telescope at *c*. The reading telescope was reversible in its Y supports, and was adjusted by reference to the cross-wires of the telescope, *a*. The declination-magnetometer was a bar-magnet having a finely divided scale, on glass, fixed to one extremity, and a lens at the other, the scale being adjusted to the solar focus of the lens. The bar was suspended at its middle by means of a stirrup admitting of reversal, which was attached to the horizontal axis of the torsion-circle above, by means of silk fibre thirty inches in length, and the whole enclosed in a mahogany case provided with sliding apertures, a lamp, and a reflector for throwing light obliquely upon the scale, for the purpose of rendering the fine lines and figures more distinctly visible. The recesses *g*, *g*, in the building, on each side of this instrument, were intended to be used in observations for total intensity.

The *Horizontal Force* magnetometer was placed at *c*, and its reading telescope at *f*. This magnetometer consisted of a steel bar similar to that of the declination instrument; but it was suspended by a loop of fine silver wire passing round a pulley below, and into the grooves of a finely threaded screw above. There were several pulleys of different diameters, for the purpose of varying the amount of separation between the two strands of the wire, and consequently that of torsion, it being required that the magnetized bar should be held in balance of the earth's horizontal magnetic force when in a position nearly at right angles to the magnetic meridian. The scale and lens were enclosed in a brass tube, which admitted of being turned horizontally to the position where the scale-division might be well seen through the reading telescope when in the position perpendicular to that of the magnetic meridian.

The *Vertical Force* magnetometer at *d* was a steel bar fourteen inches in length. It was nicely balanced on an agate knife-edge, and had apertures with cross-hairs at each end of the bar. The reading was performed by the aid of two micrometer microscopes placed opposite the cross-wires. All the magnetometers were protected from disturbing currents of air by close fitting mahogany boxes, provided with glass slides and tubes.

In selecting positions for these instruments regard was had to their mutual disturbance. The most favorable appeared to be the following, which were accordingly adopted.

The distance from *b* to *c* was thirty-six feet nine inches; from *b* to *d*, thirty-six feet two inches; and from *c* to *d*, forty feet six inches. The distance of the fixed reading telescopes *e* and *f* from *b* and *c*, respectively, was seven feet, and from *a* to *b*, thirty feet. The direction *a b* is that of the magnetic meridian, approximately; *a c* is perpendicular to it. The point *c* was so selected, that the angle which the line *b c* made with the magnetic meridian at *b* was equal to 35°.

The distance of the Gauss apparatus from these magnets was a sufficient security against any important disturbing effects arising from that source. The supports of all the instruments were of red-sandstone, having their foundations about four feet below the surface; these were insulated from the floor of the building, and protected from the effects of frost by a covering of tanner's bark, an excellent non-conductor of heat. The sandstone had been previously tested, and found to exert no appreciable influence on the magnetic needle.

The barometer by Cary was freely suspended from one of the upright stanchions of the building, at *h*. Several thermometers, which had each been compared with the standard, were placed on the outside of the east, west, and north windows. A freestone stove, a writing-table, a few chairs, and a couch where the observer, when off duty during the alternate hours of the night, might take rest, completed the furniture of the Lloyd Magnetic Observatory. The arrangement of building and instruments was found to be convenient, a comfortable temperature being easily preserved during even the most inclement weather.

The Lloyd magnetometers had been manufactured by the same persons who had prepared those for the magnetic observatories established in different quarters of the globe by the British government; the principal stations being Greenwich, at the Royal Observatory, Toronto in Upper Canada, the island of St. Helena in the South Atlantic, the Royal Observatory at the Cape of Good Hope, and the meteorological observatories at Bombay, Madras, and Singapore, in the East Indies, and Hobarton, Van Diemen Island. Our purpose being to co-operate with the observers stationed at those places, it became desirable that the instruments should be as nearly similar, both in principle and construction, as it was possible to make them, in order that the results obtained might be the more safely, as well as more directly, compared.

The next point to be considered, after making this arrangement of the instruments, was the amount of time that could prudently, and consistently with other engagements, be devoted to the different branches of inquiry to which they were adapted. The periods recommended by the committee of the Royal Society, after consultation with the German Magnetic Association, were, first, the four terms previously adopted by the German Association. These occur in the months of February, May, August, and November, commencing on the Friday preceding the last Saturday of the month, at $10^{h.}$ P. M., Göttingen mean time. To these were to be added eight additional terms, to be held on the Wednesdays nearest to the 21st of the eight remaining months. The hour of commencement was the same in both cases. The Russian government had decided upon uninterrupted observation at their observatories, which were distributed over an immense extent of territory, from the borders of China and Asia Minor to the Arctic circle. As our observations were to be continued during the night as well as the day, and also through the different seasons of the year, and as every individual connected with the undertaking had other duties mainly to engage his attention, it was deemed most prudent to attempt no more than the term-day series; that is, certain Wednesdays and Fridays of every month in the year, to be specially devoted to the continuous observation of terrestrial magnetism and meteorology.

A regular course of observation, according to the system recommended by the "Committee of Physics, including Meteorology," of the Royal Society of London, was commenced on the 27th of March, 1840, and continued to the 23d of March, 1843. During the latter part of this period, the members of the Senior, Junior, and Sophomore Classes in the College associated themselves under the name of "The Meteorological Society of Harvard University," for the purpose of filling up the vacancies occurring between the term-days with observations on the barometer, thermometers, and the three elements of the earth's magnetism, during every day and night, at intervals of two hours, one hour, or half an hour, as other duties rendered it convenient.

The association continued these observations during a period of more than a year, with remarkable assiduity and success. The results were arranged and discussed by Professor Lovering, assisted by Mr. Thomas Hill, of the Senior Class, and Professor Peirce, and were afterwards published by the Academy in the second volume, new series, of its Memoirs.

The engrossing nature of continuous magnetic observations was found to interfere injuriously with other more immediately important duties. This circumstance, combined with the loss which the Observatory sustained in November, 1842, by the death of W. C. Bond, Jr., who had, notwithstanding his engagements as a student in the College, voluntarily devoted himself to the interests of the Observatory from its first establishment, by daily and nightly labors, both in observing and computing, rendered it necessary, on the completion of the term first agreed upon, to defer a second engagement for the prosecution of continuous magnetic observations until such time as the funds of the Observatory would warrant the employment of several persons whose undivided attention might be given to this object. Indeed, it appeared questionable whether this branch of scientific inquiry could be successfully pursued without adopting a complete system of self-registration adapted to all the instruments.

In 1842, Mr. Bond had completed his first astronomical engagement with the government of the United States. The advantages to be derived from the co-operation of systematic observations, made at a fixed observatory, have been constantly recognized by officers engaged in extensive government surveys. Where of necessity there is frequent change of station, and portable instruments only can be used, and where great distances and long periods of time intervene, there will unavoidably accumulate, even from minute individual errors of observation, very serious discrepancies; and it is in correcting these accumulating errors that fixed observatories become useful to the surveyor. Whether he may be prosecuting his researches on the land or the ocean, on the borders of Canada, in the forests of Oregon, or on the banks of the Gila, he muſt continually rely upon what has been done or is doing at some fixed observatory, especially in correcting the absolute positions of the stars which he employs in determining his latitudes, and of the moon for his longitudes, by corresponding culminations, occultations, and eclipses. This kind of information has been constantly sought for by surveying parties, and furnished by the Observatory at Cambridge, and it may be confidently affirmed that no other Observatory in the United States has contributed so extensively to this latter object.

The utility of such institutions became so apparent, that the movement at Cambridge was immediately followed by the establishment of the National Observatory at Washington, by an act of Congress. This evinced a striking instance of improvement in public sentiment in regard to the care which government ought to exercise towards scientific institutions having a direct bearing upon subjects of public utility. Forty years ago, when the revival of the Coast Survey was under consideration by Congress, the connection of a fixed astronomical observatory with that work was strictly forbidden by law; and so cautiously did the National Legislature proceed in this matter, that, when such an institution could no longer be deferred, it was finally established under the name of a "Depot of Charts and Instruments." It is sufficient to say, that the advantages and honorable distinction which the National Observatory at Washington has conferred upon the country are, at the present day, unquestioned.

## SECTION III. *The New Observatory.*

THE observers at Cambridge continued to occupy themselves in such investigations as their instrumental means enabled them to pursue, until the beginning of March, 1843, when, upon the sudden appearance of a comet of surpassing size and splendor, Cambridge was naturally appealed to, in this neighborhood, for information in regard to its character and movements. An opportunity was thus afforded of representing to the public the instrumental deficiencies of the Observatory for accomplishing the more refined and difficult operations in practical astronomy. The Observatory had not in its possession a parallactic instrument or a micrometer of the least value for such purposes. The comet was in close proximity to the sun, and could be seen only for a short time after sunset. An altitude and azimuth instrument which had been used in the Massachusetts Survey was kindly loaned to supply the want of a more appropriate apparatus, and was mounted in the cupola on the top of the house, and some rough observations of the comet's place obtained on different evenings; but it was found impossible to secure permanent adjustments. While the observers were engaged in attempts to obtain approximate data for computing the elements of the comet, and to answer some of the many inquiries that were made, a meeting of a few individuals, who were desirous that the deficiency should no longer exist, took place at the office of J. I. Bowditch, Esq., in Boston. They readily obtained the sanction of the American Academy to the calling of a meeting of citizens for discussing the propriety of procuring an equatorially mounted telescope of the first class, to be placed at Cambridge; and this meeting was accordingly held at the rooms of the Boston Marine Society in Boston. It was very fully attended by gentlemen who could not only appreciate the importance of the project, but were both able and willing to carry it into effect. The Hon. Abbott Lawrence was called to the chair, and the meeting was addressed by the Hon. John Pickering, Professor Peirce, Hon. William Appleton, and Hon. S. A. Eliot. On motion of J. I. Bowditch, Esq., the following committees were appointed:—

To obtain subscriptions, Hon. S. A. Eliot, Thomas B. Curtis, Charles A. Mills, Henry Edwards, W. W. Stone.

To prepare a report, Hon. John Pickering, Francis C. Gray, Jonathan Phillips, William Appleton, Israel Lombard.

While the meeting was yet in session, the Hon. David Sears, who had not found it convenient to attend, intimated through President Quincy his willingness to give five thousand dollars for the erection of a tower for the reception of a telescope, provided the sum of twenty thousand dollars should be contributed for the purchase of the instrument. This munificent proposal gave increased animation to the discussions, and an impetus to the proceedings which was fully sustained in all the subsequent efforts which were made for the establishment of an Astronomical Observatory.

The committee appointed for that purpose prepared a report, which was published; and the proposed amount was contributed by the citizens of Boston, Salem, New Bedford, and Nantucket, whose names are mentioned in the Appendix.

It is worthy of note, that no restriction or reservation was in any instance required in regard to a right of visiting the Observatory, or a control of its operations. This liberality, on the part of the contributors, has been productive of the most beneficial effects.

When this amount of twenty thousand dollars had been furnished for the purchase of the best and most powerful telescope that could be obtained in Europe, the question came up for mature consideration, respecting the kind of telescope that should be procured, the form of its mounting, and who were the best makers to apply to for its construction.

The superiority in defining power and convenience of management possessed by the refractor over the reflector, was decisive in favor of the former. It was also decided to adopt the parallactic or equatorial form of mounting on the plan introduced by Fraunhöfer, which had been found to give entire satisfaction when applied to the large Dorpat and Poulkova telescopes.

In order to be assured of the possibility or probability of procuring a perfect telescope of the magnitude and kind contemplated, the opinion of several of the most eminent practical astronomers and opticians in Europe was solicited, which proved favorable to the impression at first entertained, and also to the employment of Messrs. Merz and Mahler of Munich, the successors of Fraunhöfer, as its makers.

The order was accordingly given to those manufacturers. A contract was drawn up, wherein it was stipulated that Messrs. Merz and Mahler should prepare two object-glasses fifteen inches in diameter, of a quality equal to the one which they had recently furnished to the Imperial Central Observatory at Poulkova, and that, when the glasses were finished, an agent appointed by Harvard College should have the right to make a selection, or to reject both if neither should prove satisfactory.

While the telescope was in process of construction, the Corporation of the College had been directing their attention to the selection of a more favorable situation for an Observatory than the one hitherto occupied, and also to the erection of suitable buildings. The site finally agreed upon for this purpose formed a part of the Craigie estate, commonly known under the name of Summer-House Hill. It had long been a favorite resort, on account of the beautiful and extensive view which the summit afforded of the surrounding country. It is eighty feet above the level of tide water, and fifty feet above the plain, from which it rises by a gradual ascent on the eastern and northern sides, falling off abruptly on the south. The substratum of the soil was found also to be favorable to the stability of the foundations of the piers for supporting the instruments.

Fortunately the College was able to obtain, at a moderate price, about ten acres of ground including this situation, and on the 12th of August, 1843, the position where the great central pier was to be erected was marked, and on the following days the meridian and prime-vertical lines were laid off. Ground was broken for laying the foundation of the central pier on the 15th of August. The work progressed favorably till September, 1844, when, the observer's dwelling-house and a sufficient portion of the

Observatory buildings being completed, the instruments were transferred to their new positions. The small out-buildings which had been occupied at the Dana place for magnetic observations were removed to a place about sixty feet north of the new Observatory, for the temporary accommodation of some of the instruments, and there the four-foot transit, together with the declination and horizontal-force magnetometers, were replaced in position.

In December, 1844, a transit-instrument, which had just been imported by the United States government for the use of the Northeastern Boundary Commission, was mounted in the prime-vertical, and was employed during the winter in observing zenith distances of stars according to Bessel's method, for the purpose of determining the latitude of the Observatory. The use of this fine instrument, which had been lately received from Messrs. Troughton and Simms of London, had been kindly permitted for this purpose by Lieutenant-Colonel James D. Graham, of the Corps of United States Topographical Engineers, at that time principal astronomer and surveyor of the Northeastern Boundary Commission on the part of the United States, who himself participated with W. C. and G. P. Bond in making the requisite observations, which were subsequently discussed by Professor Peirce, and published in the second volume, New Series, of the Memoirs of the American Academy. The adopted latitude of the Sears Tower derived from these observations is 42° 22′ 48″.1.

The following *differences* of latitude of points in the vicinity are derived from the Massachusetts and United States Surveys: —

| | |
|---|---|
| The Observatory at Dorchester is south of the Sears Tower . . | 3′ 37″.49 |
| Old Observatory at Cambridge is " " " . . . . | 31.82 |
| The cupola of the State-House in Boston is south of the Sears Tower | 1 23.89 |

The collection of data for the determination of the difference of longitude between Cambridge and Greenwich Observatories was continued by the methods of moon culminations, eclipses, and occultations. To these, of late years, have been added several chronometric expeditions undertaken for the same object. The adopted longitude of the Sears Tower is 4$^{\mathrm{h.}}$ 44$^{\mathrm{m.}}$ 30$^{\mathrm{s.}}$.7 west of the meridian of Greenwich.

The following differences of longitude of the points above referred to have in like manner been derived from the United States and Massachusetts Surveys: —

| | |
|---|---|
| The Observatory at Dorchester east of the Sears Tower . . . . | 14$^{\mathrm{s.}}$.776 |
| Old Observatory at Cambridge " " " . . . . . . | 3.098 |
| State-House, in Boston " " " . . . . | 15.525 |

In December, 1844, a telescope of forty-six inches' focal length and two and three quarters inches' aperture, equatorially mounted, was placed on a pedestal situated one hundred and eighty feet west 30° north of the great pier. It was protected by a canvas tent on a framework, turning horizontally on cannon-balls. The instrument was provided with a spider-line position-micrometer. This telescope was afterwards exchanged for one of five feet, having the additional advantages of a ring-micrometer and one of Airy's double-image micrometers; it was mounted on the same parallactic stand, and proved of great value in extending the field of observation to comets, double stars, and other objects which were not within the range of the smaller telescope. The solar eclipses of May 6th, 1845, and April 24th, 1846, and the transit of Mercury across the disc of the sun on May 8th, 1845, were observed with care by the aid of this instrument. Particular attention was also given to the comets of June, 1845, of February and of May, 1846, and during several years to the delineation of the solar spots. With it our first observations of the planet Neptune were obtained.

Notice having been received from the makers, that the two object-glasses from which a selection was to be made for the great equatorial were ready for trial, Messrs. W. Simms and J. Cranch, of London, the agents appointed by the College, proceeded in May, 1846, to Munich, and after subjecting the lenses to the requisite experimental tests, had no hesitation in giving the preference to the one which is now mounted at this Observatory, — a decision which the favorable experience of nine years has fully justified. The report of the agents upon the subject of the selection will be found appended to the Report of the Visiting Committee of 1846.

The practice of requiring from the Director a Report on the condition of the Observatory, addressed to the Committee of the Board of Overseers of the University, at the time of their annual visitation, was commenced in 1846. The reports of these committees, from that date to 1855, inclusive, with those of the Director, and various documents accompanying them, are printed in the Appendix. They dwell so fully upon all the more prominent subjects relating to the history of the Observatory, as to render enlargement on them here unnecessary. It will not, however, be out of place to add a brief notice of such events as will serve to continue this sketch down to the present time.

The object-glass of the great Refractor was received at Cambridge on the 4th of December, 1846, and the machinery on the 11th of June, 1847. Preparations were immediately made for mounting the telescope. The details of this difficult and somewhat hazardous operation are not of sufficient importance now to require recapitulation. It was commenced on the 23d of June, and was accomplished on the afternoon of the 24th, without the slightest accident. The facility with which the ponderous body, when placed in adjustment, could be directed, and the steadiness of its motion, were then, as ever since, a source of great satisfaction.

Among the earlier objects upon which systematic observations were made with the new instrument, were the Nebulæ of Andromedæ and of Orion, both being subjected to a most careful and long-continued examination. The new and interesting features revealed were an ample compensation for the labor and attention bestowed upon them during several months.

These discoveries were doubly interesting, both as affording the strongest evidence of the excellent qualities of the instrument, and as showing that even the most familiar objects in the heavens, when subjected to its searching power, could be made to yield new accessions to the sum of astronomical knowledge. A still more decisive proof of this have been the results of the observations made upon the planet Saturn. Certainly not one of the heavenly bodies, even the moon scarcely excepted, had been so constantly under the eye of astronomers, since the invention of the telescope, as this planet, and it might have been regarded, on that account, as presenting a well-nigh exhausted field of discovery. Yet it is no exaggeration to say, that the phenomena of this unique system of rings and satellites which have come to light within less than ten years past have not been surpassed in interest by any of those which had been previously recognized. The discovery of the new inner ring; the singular fact of its transparency; the frequent observations made upon the abnormal divisions and shadings of the rings; the demonstration of their fluid nature, and of the conditions of their equilibrium; the investigation of the unexplained phenomena of the shadows projected upon the ring, and of the curious appearances presented at the time of its disappearance; and, lastly, the discovery of the eighth satellite, — are all recent additions to our knowledge of the system of Saturn, in the development of which this Observatory has taken an active part.

The investigations made by Mr. George P. Bond, on the question of the stability of the rings of Saturn, resulted in the unexpected conclusion, that the rings must be in a fluid state, as a necessary condition of their permanence. The paper containing these results was presented to the American Academy of Arts and Sciences, April 15th, 1851, and is printed in the Memoirs of that Society. The demonstration of this highly interesting fact has been erroneously ascribed to Laplace. The third chapter of the fifth book of the "Mécanique Céleste" opens with the following words: "In treating of the figure of Saturn's ring, we have seen *that each ring is a solid body*."* Indeed, the whole force of Laplace's celebrated explanation of the manner in which the rings are sustained, lies in the assumption that the separate rings are irregular *solids*.† The more recent researches of Professor Peirce have given entire confirmation to Mr. Bond's original statements.

---

* Mécanique Céleste, Vol. III. § 20.

† Ibid., Vol. III. vi. § 46.

Among the additions to the apparatus, made after receiving the great Refractor, that of a valuable comet-seeker, equatorially mounted, presented by J. I. Bowditch, Esq., was a most acceptable acquisition. For a period of six years, commencing in 1845, this instrument, and a smaller one by Dollond, the gift of President Quincy, were employed by Mr. G. P. Bond in a systematic search for comets, of which ten were independently discovered here during that interval.

The transit-circle intended to complete the apparatus was received in 1848, and immediately mounted on the granite piers which had been prepared for it in the east transit-room. The first observations with it were made November 7th, 1848. Both in the firmness of its mounting and the perfection of its motion, it is an instrument of the first order of excellence. It was found, however, to have sustained an injury, on its way from London to its destination at Cambridge, affecting the divisions of both circles, which has prevented its being employed for measurements of absolute declinations. As a meridian-transit it has been in almost daily use since the date of its mounting. This necessary and constant employment has hitherto occasioned the delay in making any attempt to correct the imperfection of its circle.

In the course of the same year (1848) the lines of the Magnetic Telegraph were extended to the Observatory, at the expense of the United States Coast Survey, with the original intention of communicating with several of its principal points for the determination of longitudes by the electro-magnetic method, for which purpose the lines have since been frequently employed, as well as for communicating to the neighboring city of Boston the exact local time.

During the seven years preceding the year 1846, no pecuniary compensation could be made to the observers. But soon after removing to the new Observatory, provision was made for the payment of salaries to the Director and his assistant for two years, by the liberality of a few citizens of Boston.* Their annual contributions constituted the whole of the pecuniary resources of the institution. The absolute necessity of a suitable permanent endowment to insure its success had, however, been always kept in view by its friends.

In 1849, a munificent bequest, contained in the will of the late Edward Bromfield Phillips, relieved this pressing want, by appropriating one hundred thousand dollars, "for and to be kept as a perpetual fund; the interest thereof to be annually applied for the payment of the salary of one or more astronomical observers at the Observatory at Cambridge; or for the purchase of instruments, or library, for the use of said Observatory, at the direction of said Corporation. The said interest, when not annually expended, to be added to the capital sum, for the accumulation thereof."

---

* For the names of contributors to this purpose, see Appendix.

The Report of the Director for the academical year 1848 – 49 notices at length his organization of an expedition, under the auspices of the United States Coast Survey, for ascertaining, by means of chronometers transported by the British and North American line of steamers, the difference of longitude between the Observatory of Harvard College and the Royal Observatory at Greenwich. The voyages were continued through several successive years, terminating in 1855.

These expeditions, for the magnitude and the completeness of their equipment, have not been equalled by any of the similar undertakings of various European governments. Even the "Expédition Chronométrique" of Struve was on a scale much less extensive. The results of the voyages made in 1849, 1850, and 1851 place the Observatory in the longitude of $4^{h}\ 44^{m}\ 30^{s}.66$ west of Greenwich, with a probable error of $\pm 0^{s}.2$. The Observatory at Liverpool, under the charge of John Hartnup, Esq., has rendered the most valuable assistance in the prosecution of this work.

Very complete series of electro-magnetic communications have connected the Observatory intimately with the stations of the Coast Survey in distant parts of the country. The results of the chronometric longitudes are thus rendered available throughout the whole extent of the continent. In the following report to the Superintendent of that work, it may be seen upon what grounds Harvard Observatory was adopted, by Professor Walker, as the zero of longitude of the United States Coast Survey, in 1851.*

"*Abstract of Reports on Longitudes, by Sears C. Walker, Assistant in the Coast Survey, to the Superintendent.*

"Cambridge, September 30, 1851.

"DEAR SIR: — I beg to submit an abstract of all my reports on longitude hitherto made.

*Harvard Observatory, west of Greenwich.*

| | h. | m. | s. |
|---|---|---|---|
| (A) By moon-culminations, at Harvard, 1843 – 1845, | 4 | 44 | 28.47 |
| " " " Hudson, Ohio, 1838 – 1844, | | | 28.62 |
| " " " Wilkes's Observatory, 1838 – 1842, | | | 28.52 |
| " " " Washington Observatory, 1845, | | | 28.06 |
| Mean by moon-culminations, | 4 | 44 | 28.42 |

(B) By eclipses, transits, and occultations, —

| | h. | m. | s. | Weight. |
|---|---|---|---|---|
| At Dorchester and Harvard, 1820 – 1840, | 4 | 44 | 32.16 | — 6.4 |
| " Brooklyn, New York, | | | 31.22 | — 0.4 |

---

* See Report of the Superintendent of the Coast Survey for the Year 1851, pp. 480, 481.

| | h. | m. | s. | Weight. |
|---|---|---|---|---|
| At Philadelphia, 1769 – 1840, | 4 | 44 | 32.56 | — 2.5 |
| " Wilkes's Observatory, 1838 – 1842, | | | 33.13 | — 1.0 |
| Mean by eclipses, transits, and occultations, | 4 | 44 | 32.27 | —10.3 |

"These phenomena have been reduced by Burckhardt's Tables, and include, on the average, the constant error of his parallax of the moon. Airy, in his reductions of the Greenwich observations of the moon, makes the correction of this parallax to be $\varDelta \pi_0 = +1''.78$. Professor Peirce and myself have computed the average value of the coefficient $\left(\frac{\Delta d}{\Delta \pi}\right) = -1^{s}.5$, whence $\left(\frac{\Delta d}{\Delta \pi}\right) \times \varDelta \pi_0 = -2^{s}.67$; and $4^{h.}\ 44^{m.}\ 32^{s}.27 - 2^{s}.67$ is:—

| | h. | m. | s. |
|---|---|---|---|
| (B′) Corrected mean by eclipses, transits, and occultations, | 4 | 44 | 29.60 |
| (C) By chronometers with Liverpool,— | | | |
| Indiscriminate mean of 373 chronometers in all, | 4 | 44 | 30.92 |
| " " 175 " (great special exp. of 1849,) | | | 30.96 |
| Bond's " " " " " " " | | | 30.10 |
| (C) Adopting the last value, | 4 | 44 | 30.10 |
| (A) Longitude of Harvard Observatory, | 4 | 44 | 28.42 |
| (B′) " " " | | | 29.64 |
| (C) " " " | | | 30.10 |
| Adopted for the present, Harvard Observatory, | 4 | 44 | 29.05 |

"Then we have, by the telegraph operations of the Coast Survey, the following results from Greenwich, depending on this assumed longitude of Harvard Observatory:—

| | h. | m. | s. |
|---|---|---|---|
| New York (City Hall), | 4 | 56 | 0.150 |
| Philadelphia Observatory, | 5 | 0 | 37.504 |
| Seaton Station (Washington, D. C.), | 5 | 7 | 58.564 |
| Capitol, Washington, | 5 | 8 | 0.853 |
| Wilkes's Observatory, | 5 | 8 | 0.958 |
| Washington Observatory, | 5 | 8 | 11.206 |
| Georgetown Observatory (Georgetown, D. C.), | 5 | 8 | 17.206 |
| Charleston Observatory, S. C. (Sec. V.), | 5 | 19 | 43.832 |
| Savannah Exchange (Sec. V.), | 5 | 24 | 20.572 |
| Hudson Observatory, Ohio, | 5 | 25 | 43.205 |
| Cincinnati Observatory, | 5 | 37 | 58.062 |

"The following results depend on moon culminations and occultations:—

| | h. | m. | s. |
|---|---|---|---|
| Sand Key, Florida (Sec. VI.), . . . . . . . . . . | 5 | 27 | 31.641 |
| Moro Castle (Havana), . . . . . . . . . . . . . | 5 | 29 | 24.000 |
| Point Conception (Sec. X.), . . . . . . . . . . . | 8 | 1 | 42.640 |

"Respectfully submitted,

"SEARS C. WALKER, *Assistant Coast Survey.*

"PROF. A. D. BACHE, LL. D., *Superintendent Coast Survey.*"

In 1851, the original plan of the buildings was completed by the erection of the western wing; the funds required for the purpose having been supplied by the continued liberality of private individuals in Boston.*

This addition afforded proper apartments for several instruments which before had been only temporarily mounted. The five-foot equatorial was transferred to a dome which had been provided for it over the centre of the building, and was supported by a granite pedestal on a framed and insulated pier. The basement furnished a hall for magnetic and other experiments. The rooms on the first floor were designed for a library, computing-rooms, &c.

The application of electro-magnetism to the purposes of practical astronomy, from the moment when the idea was first conceived, was full of promise of becoming the most valuable of modern improvements in the department of exact observation. Nor were these hopes destined to disappointment. Through its agency our national surveys have acquired a degree of exactness altogether unattainable by the methods which it has superseded, and our principal American Observatories would now as soon think of restoring the antiquated apparatus of Tycho Brahe, as of relinquishing this admirable method of registration.

The method did not at once reach its present maturity. The plan now in use at Cambridge is, however, essentially the same with that proposed in 1848–49, but has been modified in some of its details. A full account of this apparatus in its present form will be found in the Description of the Observatory. It was by the electric method, as at first devised, that the Zone Observations published in the second part of this volume were recorded. The series of zones, commencing in 1852, has been continued, with some improvements, to the present time (1855), and will be prosecuted as rapidly as is consistent with the correct publication of the results. The catalogue now numbers upwards of 10,000 stars. Nearly the whole of these have been twice observed.

The development of the new method having been closely connected with the operations of this Observatory, its history may with propriety be here alluded to in a more detailed manner. In regard to the vexed question of the original invention, we give the subjoined *official* report made on this subject by Professor Sears C. Walker to Professor A. D. Bache, Superintendent of the United States Coast Survey, whose sanction has been given to its publication.

---

* Vide Appendix.

"Washington, D. C., April 24, 1851.

"To Prof. A. D. Bache, LL. D., *Sup't U. S. Coast Survey.*

"Dear Sir, — In compliance with your instructions, I beg to submit a brief abstract of the progress of improvement and invention in the art of determining longitudes by the Electric Telegraph. They are taken from the records of the Coast Survey, on file in the office, and can be substantiated by them.

"Yours, respectfully,
"Sears C. Walker,
*Assistant U. S. Coast Survey.*"

"1st. 1844, June 9th. Captain Charles Wilkes, U. S. N., made the first experiment for determining longitudes by the electric telegraph, between Washington and Baltimore, with chronometers rated at each place, without using coincidences of beats of solar and sidereal time-keepers. Professor Bache had previously applied to Dr. Morse for the use of the government's telegraph line for this purpose; but was informed that it was already engaged by Captain Wilkes.

"2d. With the above exception, all the experiments for determining longitudes by the electric telegraph, in the United States, have been made at the expense of the Coast Survey, and by its officers, or by their request, and under their immediate supervision.

"3d. 1846, October 10th. Star-signals were first exchanged between the Washington Observatory, and that of the Central High School of Philadelphia. The outfit of telegraph junction-lines and apparatus was made by the Coast Survey. The use of the astronomical instruments for the occasion, at the Washington Observatory, had been offered to the Coast Survey, by Lieutenant Matthew F. Maury, U. S. N., Superintendent. The experiment was made under the charge of Sears C. Walker, Esq., one of the assistants of the Coast Survey; who from that time to the present, under an appointment from Professor A. D. Bache, LL. D., Superintendent, has had uninterrupted charge of this work.

"The apparatus used this evening was devised and constructed by Joseph Saxton, Esq. The star-signals, or taps on a make-circuit finger-key, at the instant of the passage of a star over a wire of a transit-instrument, were made that night by Lieutenant J. J. Almy, U. S. N., and were recorded by the ear by Mr. Walker and Lieutenant J. M. Gilliss, U. S. N., at Washington, and Professor E. O. Kendall, Director of the Philadelphia High School Observatory at Philadelphia. The longitude between the two stations, by this night's work, agrees within $0^{s}.2$ with the average of all the work done since.

"4th. 1847, July 27th. Coincidence of beats of solar and sidereal chronometers were, for the first time, tried between Philadelphia and Jersey City. These coincidences were noted, at each place, by comparison of a solar and sidereal time-keeper. The circuit of the telegraph line was closed temporarily every ten seconds, by the astronomer at one of the stations, and the receiving magnet-beats were heard sensibly at the same instant of absolute time at both stations. The dates of coincidences of these magnet-beats with the stationary clock-beats (the one being at solar, the other at sidereal time) were recorded at both stations. This experiment was repeatedly performed that year by Mr. Walker, assisted at Philadelphia by Professor E. O. Kendall, Director, and at Jersey City by Professor E. Loomis.

"5th. In July and August, 1848, an extensive series of star-signals, and clock-signals by coincidences, were exchanged between the Harvard Observatory at Cambridge, and the Observatory in the garden of the late Peter Stuyvesant, in New York city. The work was under the charge of Mr. Walker, assisted, respectively, by William Cranch Bond, Esq., Director at Cambridge, and Professor E. Loomis, at New York city. During these experiments, Mr. Bond conceived the idea of using an automatic circuit-interrupter, and, on the recommendation of Mr. Walker, received, in August, 1848, an order from Professor Bache, Superintendent, for the construction of a clock for this purpose, in conformity with Mr. Bond's drawings, then before the Superintendent. This clock was completed in 1850, and forms part of the apparatus in use at Cambridge in 1850 and 1851. The work of 1848, in July and August, forms the date of the first connection of Mr. Bond and his two sons, Messrs. George P. and Richard Bond, with the use of the magnetic-telegraph line for longitudes, and with the machinery and apparatus for the same. It preceded, by two months, the work between Philadelphia and Cincinnati of the year 1848, when, in the month of October, the attention of Professor O. M. Mitchell, and afterwards of Dr. John Locke, was turned to the subject.

"The fact that Professor Bache had ordered an automatic circuit-interrupter of Mr. Bond in the preceding August, was communicated both to Professor Mitchell and Dr. Locke previous to their undertaking similar experiments.

"6th. 1848, October 26th. Professor O. M. Mitchell, at the suggestion of Mr.

Walker, prepared a circuit-interrupter, with an ordinary eight-day clock, and used it to graduate the running fillet of paper for several days. It was not used in the work with Philadelphia, clouds having prevented work on the night of the 27th, proposed for the purpose. The same mode which Professor Mitchell used had been proposed by Joseph Saxton, Esq., in 1846, but has not been adopted by Professor Bache and Mr. Walker, from apprehension of injury to the performance of the astronomical clock, which must be used for the purpose. This apprehension we know, by experience, to have been groundless.

"7th. 1848, October 26th. Dr. J. Locke, having stated his objection to Mr. Bond's contrivance of a circuit-interrupter, was requested by Mr. Walker, on behalf of the Superintendent, to undertake experiments to obviate the defects which he supposed to exist in Mr. Bond's method. These supposed defects, as it is now known, did not exist. Mr. Bond's plan of August, 1848, succeeds admirably.

"8th. 1848, November 17th. Mr. Walker, on receiving notice from Dr. Locke that he and his sons had completed an automatic circuit-interrupter, extended a junction-wire from the Cincinnati telegraph office so as to embrace Dr. Locke's clock at his house, fitted up as a circuit-breaker, with a tilt-hammer struck by the teeth of the escapement-wheel. Mr. Walker also, acting for the Coast Survey, engaged the use of the line from Louisville to Pittsburg, to try the experiment with Dr. Locke's contrivance. No astronomical nor clock signals were exchanged this evening, and no attempt was made to determine longitudes. In this experiment Dr. Locke's clock graduated a fillet of paper, as delivered by the Morse register. The graduation was automatic; in this particular, Dr. Locke was anticipated several weeks by Professor Mitchell.

"9th. 1849, January 19th. The first actual experiment of the automatic imprint of star-signals on a time-scale was made between Philadelphia and Cincinnati. The telegraph line from Philadelphia to Cincinnati was engaged for the use of the Coast Survey, by Mr. Walker. The automatic clock-interrupter was furnished by Dr. Locke, at Cincinnati. The star-signals were given by Professor Kendall, at Philadelphia, and recorded at both places. The Cincinnati Observatory, in the absence of Professor Mitchell, could not be used for the purpose of longitudes.

"10th. 1849, January 23d. The longitudes of Cambridge, New York, and Philadelphia were determined this night by star-transit signals, given for the same star as it passed the meridian of these three stations. These signals were recorded at Washington, Philadelphia, and Cambridge. The arrangements were under charge of Mr. Walker. The circuit-breaking clock was prepared by Mr. Walker, on Dr. Locke's plan, and located at Philadelphia. The same clock contained a tilt-hammer interrupter, for making signals by the teeth of the hour-wheel every two minutes. This instrument was invented in the year 1847, by J. J. Speed, Esq., President of the Telegraph Company at Detroit, Michigan. Professor Bache, Superintendent, was present at the Washington telegraph office during the experiment.

"11th. The detection of a delay in the transmission of the galvanic inducing-waves, proportionate to the space traversed, was made by Mr. Walker, immediately after examining and comparing together the registers of the four stations. It was reported immediately to the Superintendent, and by him communicated to the American Philosophical Society, and published in their proceedings for March 16th, 1849. The velocity of the galvanic inducing-waves, by the experiments of that night's work, was computed by Mr. Walker to be 18,700 miles per second. All the experiments of the Coast Survey up to this time, on the average, make this velocity 15,400 miles per second, with perfect uniformity. In a continued series of operations in 1849, 1850, and 1851, with different varieties of lines, of degrees of insulation, of power of batteries, of relation of the poles of batteries, of relative positions of the signal and receiving station, there is not a solitary instance of the exchange of arbitrary signals on a clock-scale, recorded at two stations, two hundred miles apart, (the clock and signal stations being as far apart,) in which this value of 15,400 miles per second has not been manifested. The uniformity is so great, that the difference between the observed and computed wave-time is nearly insensible, while the numerical value experimented upon has sometimes reached to more than the tenth of a second.

"12th. The next step in the progress of contrivances for mechanical imprints was made by Professor Mitchell, in the summer of 1849. His revolving disc has become generally known, and is an admirable instrument for recording dates of star-signals.

"13th. 1849, July 20th. Mr. Saxton completed his machine for registering by a metallic cylinder, or by a sheet of paper wound round a wooden cylinder. He arranged a tilt-hammer, struck by a projecting piece of glass from the middle of the pendulum, which acts as a circuit-breaker.

"He also contrived an apparatus for marking on the sheet the $0^{m.}$, $5^{m.}$, $10^{m.}$, &c., by the omission of one or two breaks respectively. Mr. Saxton's apparatus has been in use ever since at the Seaton Station. Its only defect is the want of uniformity in the time of revolution of the cylinder.

"14th. 1850, April 12th. Mr. William Cranch Bond submitted to the inspection of Professor Bache a model of an invention, made jointly by himself and his two sons, Messrs. George P. and Richard F. Bond. This instrument has been named the Spring-Governor. A perfect working instrument was ordered for the use of the Coast Survey, by the Superintendent at that time. The model was completed, and reported upon in November, 1850. Mr. Bond's machine surpasses in excellence all devices of the kind yet tried in the Coast Survey service. The cylinder, covered with a paper, revolves once in a minute, and measures time with the precision of an astronomical clock. The sheet, when taken off, after being graduated by the clock, has the minute columns vertical nearly (being slightly spiral on the cylinder). The seconds are marked off horizontally on each minute scale. The eye seizes on the appropriate hour, minute, and whole second, as in an ordinary astronomical table. The fraction of a second may be estimated to a tenth by the eye, or read to a hundredth by a graduated horn scale. A year's work of an ordinary observatory may be bound up in a volume of a few hundred pages, and forms a permanent and legible record of the actual dates of the imprinted transit-signals. Mr. Bond's method is likely to supersede all other methods yet known."

This report of Professor Walker exhibits the information on this point which he was enabled to gather from all accessible sources, including the records of the Coast Survey office, and it is not probable that a more impartial statement of the case will ever be obtained.

Before the introduction of electro-magnetism into the Observatory, there were various methods in use for recording the time of the occurrence of an event, but none of them were entirely satisfactory. The most obvious one was to employ an assistant to watch the time-keeper, and for the observer to utter, at the proper moment, some sharp outcry, or short word, as "mark," "time," "stop," or the like; the time shown by the chronometer was then noted by the assistant. It was, however, found that an indefinite portion of time elapsed between the observer's giving the signal, and its apprehension by the assistant; besides, it occupied the time of two persons. An improvement on this method was resorted to by the observer, in taking up a second from the clock-face, and subsequently listening to and counting the beats, and then estimating the fraction of a second. But it would happen occasionally, during high winds or sudden disturbances, that he would become bewildered while watching the progress of a star across the field of view of his telescope, and lose the sequence of the seconds. In order to obviate this difficulty, so far as the sense of hearing was concerned, Dr. Maskelyne, the Director of the Royal Observatory at Greenwich, introduced what was called the "Journeyman Clock." It was constructed in such a manner as to give a loud, sharp beat, and previous to the time when an observation was to be taken, it was set in coincidence with the standard time-piece. By this device the observer was rendered more certain of the right whole second, but there yet remained the difficulty of subdividing the seconds correctly; and moreover, it introduced a new source of error, in the occasional want of coincidence of motion of the two pendulums. The use of the "Journeyman" was therefore abandoned, and astronomers returned to the former method of listening to and counting the beats of the standard clock, and estimating the distance of the star from the wire of the transit, at two successive seconds. Notwithstanding the utmost precaution used while pursuing this method, it was found that different observers would arrive at different results, and this discrepancy would sometimes amount to a second or more of time, between practised astronomers. It therefore became necessary to endeavor to establish the relation in which one observer stood to another whenever their observations became an object of comparison. This relation, or difference, is called "personal equation." But this also has been found to be a variable quantity between the same individuals at different times and under different circumstances.

A third method, and the one which had been generally practised by the observers at Dorchester and Cambridge, was by the introduction of a portable half-second chronometer, which was previously and subsequently to an observation compared with the astronomical clock. The chronometer was placed near the observer at the instrument, and no further attention than to be sure of being able to hear its beats distinctly was required, until the moment that the star passed the wire; the following beat of the chronometer was then taken up, and the fraction of the *half*-second estimated; four successive beats were then counted; these two seconds afforded the observer sufficient time to turn to the face of the chronometer and read off the time indicated by it at the last beat, which time, minus two seconds and the estimated fraction, was recorded as that of the observation. The apparent advantage of this plan was, that it limited the error to half a second, and when using the method of coincidences in comparing the watch with the clock, the error attributable to that source was exceedingly small.

This may be considered as the condition of the question previous to the adoption of the electric method. It is unnecessary to give in this place a description of the electric apparatus, as that will be included in the description of the Observatory. The mode of operating with it is to secure a sheet of paper on the cylinder of the spring-governor, and, after putting the machinery in motion, to close the galvanic circuit at a given second of the clock. The cylinder is then carried round in precisely a minute of sidereal time, and the pen, operated by the electro-magnet, records each second by a momentary offset on the paper. The observer then places himself at his telescope and takes in his hand a break-circuit key, this kind of key forming a connecting link in the circuit-wire, being provided for each instrument; he is then prepared to make any record that may be required, as a slight pressure or tap on the key will be instantly responded to by the pen of the spring-governor, and consequently a written record is made on the sheet of paper. Continuous observations during two hours may be thus registered; it would not be difficult to extend them to twenty-four hours, but the size of the paper required in this latter case would be inconveniently large. For reading the sheet as it comes from the cylinder, it is only necessary to mark each alternate horizontal line of minutes on the left-hand margin, and the zero of 0 seconds, or the even minute, on the vertical column, at the top or bottom, and then, by the aid of a scale extending the whole length of the paper, and having corresponding second-spaces marked and numbered upon it, the hour, minute, second, and tenth part of a second are readily distinguished; and when extreme accuracy is required, a minutely divided scale of proportional parts is used for subdividing the second into hundredth parts.

Some of the advantages of this method consist in the permanent and legible record which is effected at the moment of observation, the reduction of uncertainties attributable to personal equation, and the greater number of observations that can be recorded in a given time, with more accuracy than could possibly be accomplished by any of the old methods.

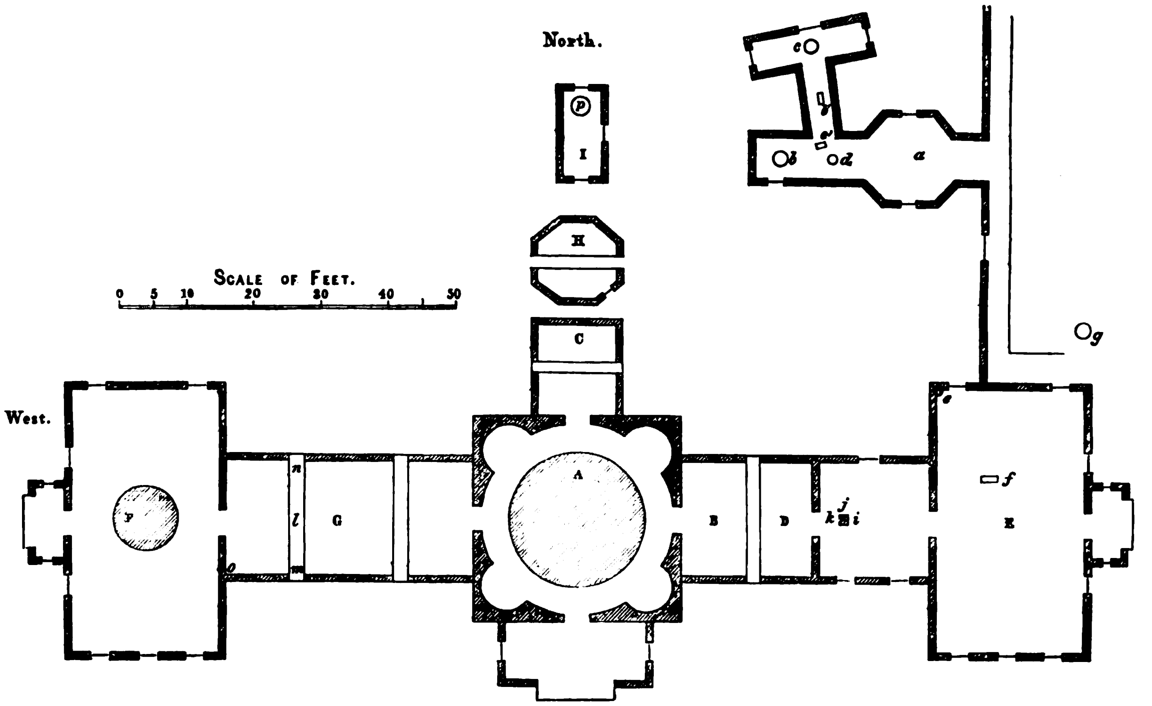
The second part of this volume contains a Catalogue of 5,500 Stars situated near the Equator, with explanatory remarks on the method pursued in determining their places. The right-ascensions of these stars were determined exclusively by the electric method. The Catalogue is believed to present the first example of an extensive and systematic application of the new process to the work of an Astronomical Observatory. Since its publication, the number of stars determined has been increased to 10,000.

The Report of the Director for the year 1855 notices the latest incident of importance to the welfare of the Observatory, namely, the provision which has been made, and of which this volume is the first-fruits, for the perpetual publication of its Annals, by the appropriation of a fund resulting from the will of Josiah Quincy, Jun., who died in April, 1775. The direction given to this bequest we owe to the generous spirit in which the son of the donor has interpreted its original conditions.

## SECTION IV. *Description of the Observatory and Instruments.*

THE annexed ground plan of the new Observatory shows the present situation of the instruments. Although several years have been occupied in its completion, the original plan has only in a few instances been departed from.

Fig. 3.



In Fig. 3, the letter A indicates the position of the grand central pier, for the support of the equatorial; the foundation of this pier is twenty-six feet below the natural surface of the ground, and consists of a mass of grouting composed of Hoffman's cement intermixed with coarse gravel; it is twenty-two feet in diameter, and ten feet in depth. When this mass had become thoroughly consolidated, the building of the pier was commenced by laying large blocks of Quincy granite in a circular manner within the border of the concrete foundation, those blocks on the circumference being four feet in length by two feet in thickness, the inner blocks diminishing in length with the diminished radius, breaking the joints in regular succession. It was built entirely solid to the height of eleven feet above the foundation. Its form is that of the frustum of a cone, twenty feet in diameter at the base, and ten feet in diameter at the top, rising thirty-three feet to the floor of the dome, where it is surmounted by a circular granite cap-stone ten feet in diameter and twenty-two inches in thickness. Upon this stands a granite tripod, eleven feet in height, weighing eleven tons, to the top of which the bed-plate of the equatorial mounting of the telescope is secured.

In building this pier, the mason was very careful in fitting each block to a steady bearing on the course below, before any cement was introduced; no iron clamps were used in its construction, and the joints were regularly broken by the superincumbent blocks. The cement is now nearly, if not quite, as hard as the stone itself, and it is difficult to conceive of a more solid structure.

The granite pedestal to which the metal bed-plate of the equatorial mounting of the telescope is attached, has been called a "tripod," from the circumstance of its resting on the capstone by three bearings, so situated in regard to the centre of gravity of the whole block, and telescope, that each bearing supports a nearly equal share of the weight. These bearings are rounded protuberances, left when the stone was worked. This method has been adopted in building all our piers, as it insures the utmost steadiness, while it admits of a ready change of position. Of this we have had ample evidence; an instance of which occurred in the mounting of the great equatorial, when the azimuth screws for adjusting the polar axis came home before the adjustment was completed. By the application of a jack-screw to the base, in the line of the two northernmost supports, and gently relieving them, the whole pedestal and telescope, weighing some fifteen tons, was moved into the required position round the third support as a centre, without perceptible jar, or risk of injury.

The piers for the transit-circle are situated at B, and those for the prime-vertical transit at C; having for their foundations a conglomerate or grouting similar to that used for the central pier. In these the grouting is enclosed in a pyramidal casing of brickwork, curved inward, and supporting granite blocks, each block being eight feet long, four feet wide, and twenty-two inches in thickness. On these blocks rest the tripod pillars supporting the Y's of the instruments.

In the west transit-room there are four pillars of less solid construction than those above mentioned, as they are adapted to the character of the instruments mounted upon them.

At *l*, the four-foot meridian transit is supported by granite pillars similar to those of the prime-vertical transit; but these pillars rest upon a foundation built up of granite blocks laid diagonally to the meridian. At *m*, there is a wooden column on which is placed the variation-transit of Troughton and Simms.

At *o* and *n*, respectively, are the framed pillars supporting the Lloyd horizontal-force and declination magnetometers. These instruments are so arranged that the telescope of the variation-transit serves as a reading telescope for the magnetometers. The direction of the astronomical meridian is determined by making use of the larger transit as a collimator, and also by reference to terrestrial marks.

At G there is a firm tripod for magnetic observations with the Fox dip-circle. This instrument has taken the place of the Lloyd vertical-force magnetometer, the latter never having given consistent results.

At F is an octagonal framed pier for supporting the five-foot equatorially mounted telescope. This pier is thirty-six feet in height above the stone foundation, ten feet broad at the base, and three feet at the top, surmounted by a granite tripod, five feet seven inches high, to which the bed-plate of the equatorial is secured by stout brass screws, entering into nuts imbedded in the stone. On this pier the telescope is found to be sufficiently steady for all the purposes to which it is applied, namely, the observation of solar spots, eclipses, and occultations of stars by the moon. It should be understood, that every pier in the Observatory is perfectly insulated from the floors and other parts of the buildings.

The entire length of the Observatory, measured from east to west, is one hundred and seventy feet. This includes the dwelling-house of the Observer at E, which, with the computing-room and the transit-circle room at D, constitute the east wing. A mean-solar astronomical clock is situated at *f*, and a sidereal clock, which is the break-circuit electric clock, at *i*. They are both firmly supported, the former by a brick wall, and the latter by a stone pier rising from a broad and deep foundation, similar to those provided for the meridian and prime-vertical transits. These clocks have mercurial compensating pendulums and Graham's dead-beat escapements.

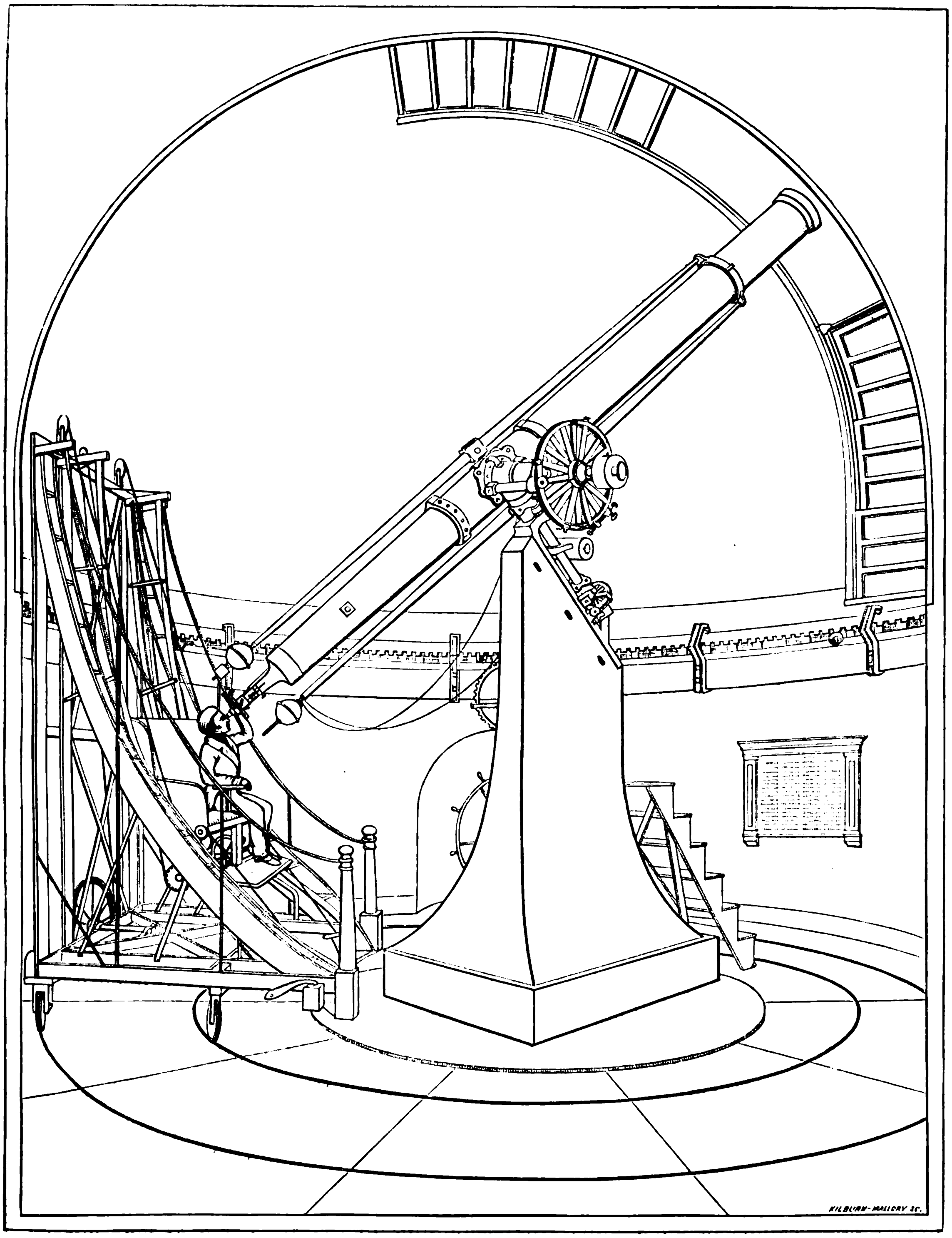
To the side of the pier *k*, opposite the clock, are fixed a standard barometer and thermometer, made by Newman, and on the north side, at *j*, is the spring-governor apparatus for recording observations by the electric method.

The central building is appropriated to the great refractor. It is thirty-two feet square. The foundations of the walls, which are two feet in thickness, are of granite, laid in cement. The walls are of brick, and also laid in cement; they are carried up square on the outside to the coving. The interior is brought into a circular form, the corners being recessed and arched in such a manner as to form a firm support to the dome.

The recesses on the ground-floor are circular, five feet in depth, and open with the chord of eight feet four inches; the ceiling is arched towards the central pier, but without touching it. There are windows at the northwest, southwest, and southeast angles. In the northeast corner is a balanced chair, for the more convenient ascending to the dome, the principal staircase being in the south portico.

In the dome-room above, the recesses are each five feet deep, with the chord of eight feet eight inches. Of these four recesses the northeastern is occupied by two closets for the safe-keeping of such apparatus belonging to the telescope as may not be in

Fig. 4.


KILBURN-MALLORY SC.

immediate use, and by the trunk in which the balance-chair traverses; the southeastern contains the machinery used to facilitate the turning of the dome; the southwestern is the ordinary entrance from the staircase; in the northwestern is deposited the comet-searcher, a celestial globe, a table, books, seats, &c., for the accommodation of the assistant.

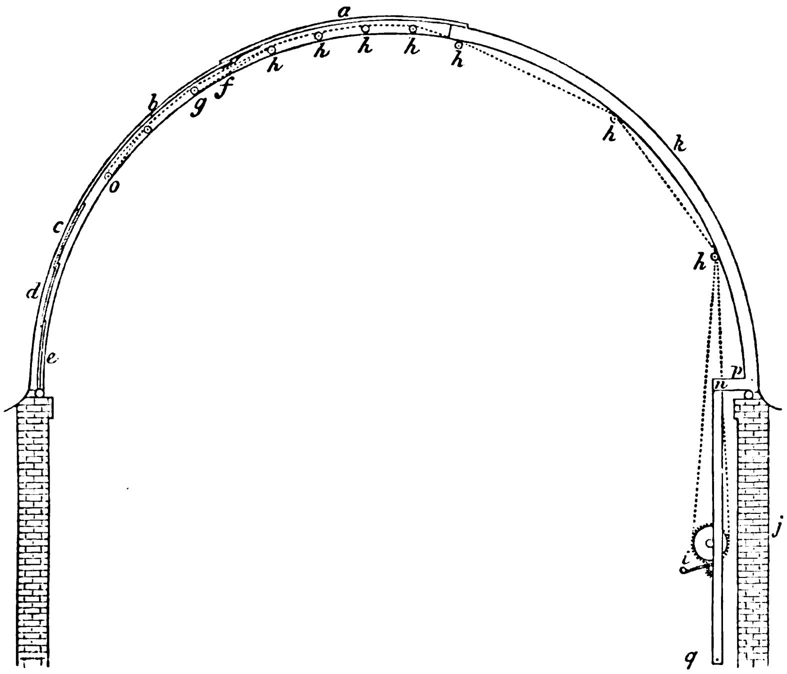
From the north, west, and east sides of the dome-room, windows open out on iron balconies, which are found to be convenient in using the comet-searcher. The platforms are of wrought-iron, with provision for readily adjusting the tripod-stand of the instrument, so as to bring its polar axis at once so nearly into the plane of the meridian, that (the axis being duly elevated to the altitude of the pole by the spirit-level) an object discovered with it in sweeping may be directly referred to the great telescope for more critical examination and measurement. The work of adjustment occupies but a few minutes, and the instrument is easily transferred from one balcony to another.

The dome covering the great equatorial is a hemisphere of thirty feet interior diameter, framed with stout ribs of plank, and having a double casing of wood, with an interspace between the two ceilings for the free circulation of air. It is covered on the outside with copper secured to a sheathing of thin boards.

The walls of the tower, called the "Sears Tower," from the circumstance of its having been built at the sole expense of the Hon. David Sears of Boston, are capped by a stone circle, one foot in thickness, by eleven inches in depth. Upon this is secured, by means of iron bolts and screws, a series of cast-iron plates, ten inches in width, grooved in a circular form to correspond to the circumference of the dome, forming altogether a complete circle. A similar iron track is laid and bolted on the lower section of the dome; and between these tracks, which had been smoothly planed, were placed eight truly turned iron balls. These spheres are eight inches in diameter, and the radius of curvature of the tracks is somewhat greater than that of the balls. In regard to spherical rollers, the experience of ten years enables us to speak with great confidence in their favor for this purpose, and to recommend their adoption in preference to any other system of wheels or rollers with which we are acquainted. If carefully examined, it will be found that this arrangement is as perfect in theory as it is appropriate and convenient in practice.

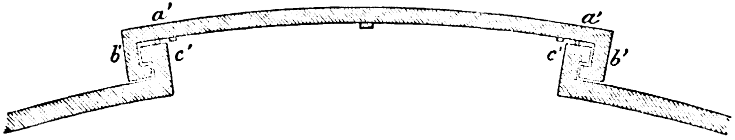
The opening of the dome extends from three degrees beyond the zenith to as many below the horizon; it is five feet wide, and the entire aperture is available by a proper management of the shutters. These are light frames of ash, covered on the outside with copper plates, and are divided into five separate compartments; the two upper shutters move on iron railways, the rollers being placed at distances of one foot apart, and secured to the inside of the shutter. Fig. 5 is a section exhibiting the manner in

Fig. 5.



which the shutters are connected with the gearing by which they are moved. At *a b c d e* they are represented as all closed. The two upper shutters, *a* and *b*, are each nine feet long; the three lower ones three feet each. A transverse section of *a* is shown in Fig. 6, where at *a′ a′*, &c., may be seen the place of bearing of the roller on the iron rail. The interlocking of the edge of the shutter with the raised edge of the opening is a provision against drifting snow, which is, at times, peculiarly penetrating. At *b′ b′*, on each side, near the ends, are like rollers, placed at right angles to *d′ a′*; these are intended as guides, and to relieve the friction which might otherwise take place, during high winds, causing a lateral pressure to an inconvenient amount, and bringing the rollers *a a* in side contact with the rail. Reference to Fig. 5, *h h*, &c., shows the track of the endless chains by which the shutters are raised and lowered by connection with the wheel-work below. At *f* there are two iron arms, which are secured to the lower end of the upper shutter, and extend about one foot downwards on the inside of the lower shutter. To these iron arms are attached, on each side of the opening, the ends of a chain, which is made like the fusee chain of a watch, only the links are each about one inch and a half long; it is perfectly flexible in one

Fig. 6.



direction. One portion of this chain, connected at *f*, leads, first, forward over a large iron pulley at *g*, and then back over pulleys situated at *h h h*, &c., down to the wheel *i*, where it passes round a toothed pulley of seven inches in diameter. The size of the teeth of this pulley are proportioned to the length of the links of the chain, thereby affording security from slipping. After passing round the pulley, the chain is carried upward over other rollers, and secured to the iron arm before mentioned, thus forming a continuous chain. It will be understood, that there is a similar arrangement for each side of each of the larger shutters.

At *p*, an iron frame, twelve feet high, and six feet two inches wide, is firmly bolted to the dome; this frame is of bar-iron three inches wide by half an inch in thickness. There are cross bracing bars, two inches wide by half an inch thick. At *q* are bolt-holes intended for attaching the observer's chair to the dome, to be carried round with it; but this plan is not in use, as, upon trial, the subsequent contrivance of a driving-wheel for the chair was found to be much more convenient. The lower part of the frame supports two axles; the interior one is solid, and passes through the other, which is made cylindrical for that purpose. The power-gearing of both is on the right-hand side of the frame, at a convenient height from the floor, consisting of two wheels, of eleven inches in diameter, one on each axle, and a double-headed pinion of three inches in diameter. To the pinion-arbor is attached a crank and handle, of one foot purchase; the pinion has an end motion, and drop-clasp, that it may be readily changed in its action from one wheel to the other. There is a toothed pulley on each end of both axles, similar to the one above described, and for the same purpose, and the other chains are operated by them in a like manner, so that either shutter may be raised or lowered independently, by turning the crank attached to the pinion. If the upper shutter is required to be moved, the pinion must be thrown into gear with the wheel on the left-hand of *i*, and if it be necessary to move the middle shutter, then the gearing of the pinion must be in the right-hand wheel.

The apparatus for turning the dome (see Fig. 4) consists of a series of toothed iron plates, arranged to a curvature of fourteen feet nine inches radius, and secured to the base of the dome by screws, forming altogether a contrate wheel of twenty-nine feet and a half in diameter, into which is geared a wheel of four feet in diameter acting vertically in a pinion ten inches in diameter. Power is gained by means of a wheel, five feet in diameter, having handles fixed in its circumference. The weight of the dome is about fourteen tons, and it can readily be moved by one person through an entire circuit in half a minute.

In addition to the security resulting from the weight of the dome, constantly tending to bring the balls to the deepest part of the curved rail, and consequently to produce a coincidence of the centres of the upper and lower circles, there are eight iron braces with rollers, fastened to the wall, as seen in Fig. 4. The rollers, acting occasionally against the interior of the dome, prevent any excessive vibratory movement which it might otherwise attain during high winds; on ordinary occasions, these rollers do not touch the dome.

The large sweep which the eye-end of the great equatorial makes in passing through an arc of 180°, renders it necessary that the observer should be provided with a convenient chair. The requisites were, a movement whereby the eye of the observer might be carried parallel to the motion of the eye-piece of the telescope, firmness and convenience of seat, and facility of manipulation. Not being acquainted with any contrivance which combined these advantages, the Director of this Observatory was thrown upon his own resources for devising the required machinery.

The following explanation of the arrangement which was finally adopted, will, it is hoped, prove sufficiently clear to enable any one, so disposed, to direct in the construction of a similar convenient, as well as durable piece of furniture.

Fig. 7 represents a sectional view of the chair. At *a a a* may be seen the wooden frame, the height of which is 13.4 feet, breadth eight feet, and depth eight feet. *b b* is a section of the box in which traverses the weight *c*, attached to the chain *d d*; this chain passes over a pulley at *f*, and is secured to the chair at *e*. There is a similar arrangement of counterpoise on the opposite side; the two balance-weights exceed the weight of the chair by one hundred pounds. The chain *g g* is attached to the upper extremity of the rail at *h*, passes half round the toothed wheel *i*, and then upward over the plain iron pulley *k*; thence downwards till it reaches *l*, where it is secured to the arm of an axle carrying a tension-weight, the purpose of which is to preserve a constantly safe gearing of the chain in the toothed wheel *i*. This may, perhaps, be more readily understood by reference to fig. 8. The chains, side and edge views of which are given in Fig. 9, are formed after the same manner as the fusee chain of a watch; the links being one inch and a half long, and, having been all struck out with the same die, uniform in size. The spaces between the teeth of

Fig. 8.

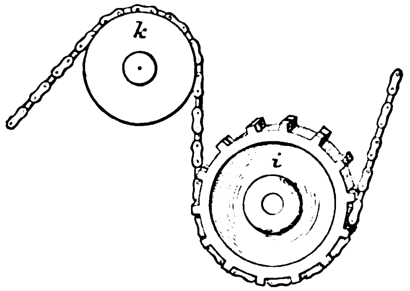


Fig. 9.

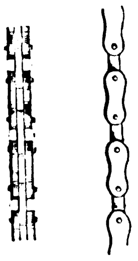
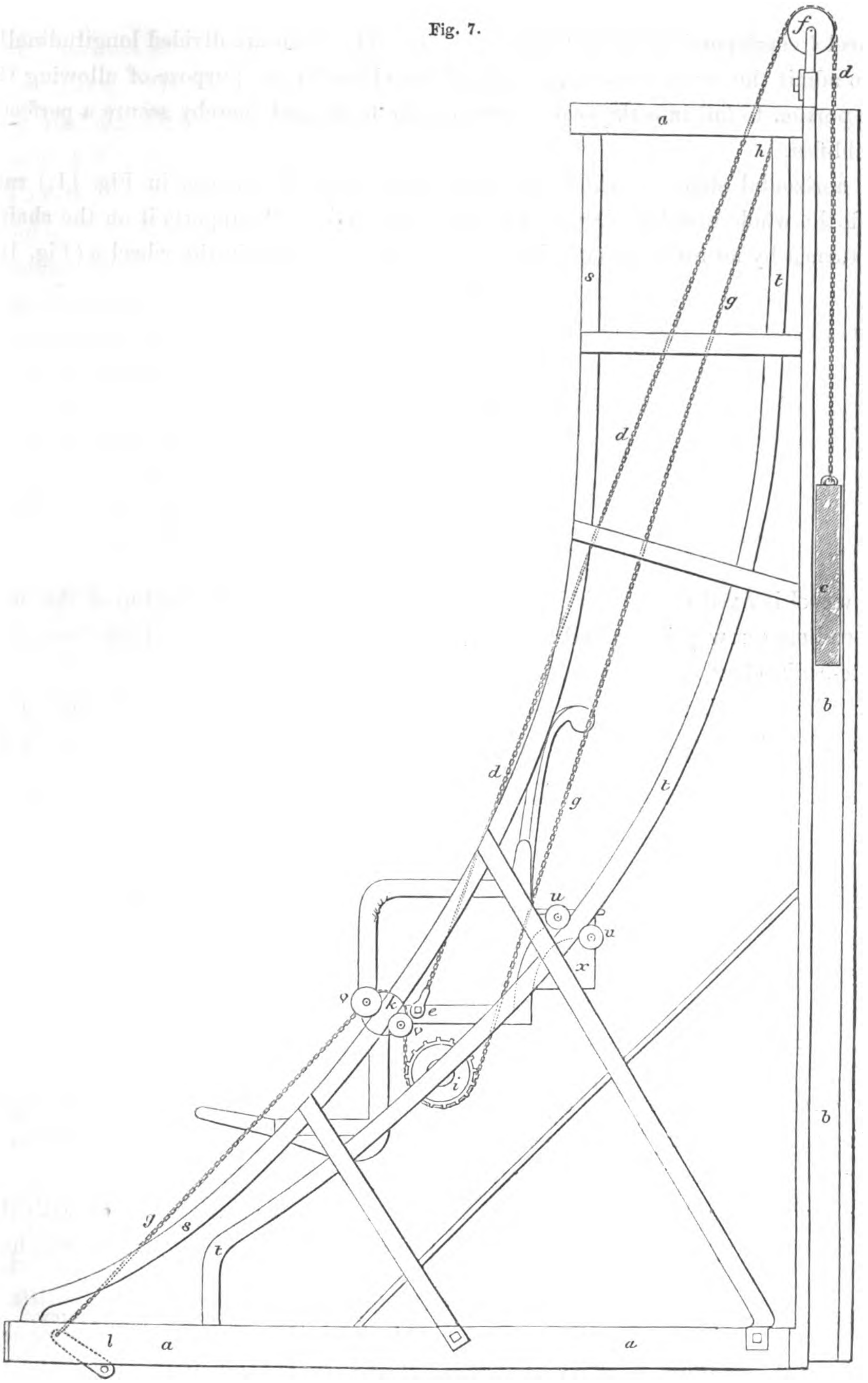


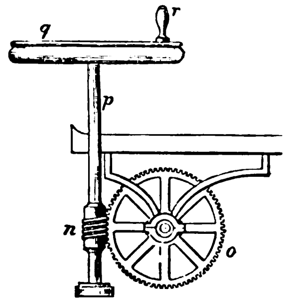
Fig. 7.



the wheel *i* correspond to the links of the chain. The teeth are divided longitudinally, so as to admit the inner connecting link of the chain for the purpose of allowing the double portion to fall into the spaces between the teeth, and thereby secure a perfectly safe hold-fast.

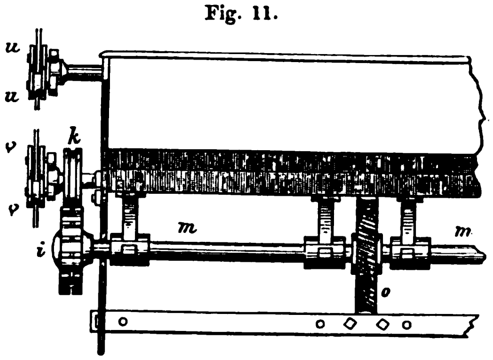
The horizontal shaft, to which the wheel *i* is attached, (as seen in Fig. 11,) runs through the whole breadth of the frame under the chair, and supports it on the chains, and is turned by means of a vertical endless screw *n*, working in the wheel *o* (Fig. 10), which wheel is fixed to the middle of the same shaft, *m m*. On the top of the shaft of the endless screw *p* is a round table *q*, serving as a convenient stand for the observer's note-book, chronometer, break-circuit key, &c.

Fig. 10.



It will be seen, that, by turning the handle *r*, motion will be communicated to the shaft *m*, Fig. 11, which is attached to the seat of the chair, in such a manner as to elevate or lower it as occasion may require. The endless screw* was selected for this purpose, in preference to any form of ratchet or lever mechanism, on account of its greater security against accidental slipping, and more ready reversal of motion.

Fig. 11.



In order to cause the eye of the observer to move in a curve concentric with that described by the eye-piece of the telescope, and at the same time to preserve the horizontal position of the seat, two curved iron rails are fastened to the frame on each side of the chair. On these rails the chair moves in the required curve, being partially supported and directed by them in front, and at the back by rollers acting on the rails, as seen in Fig. 7.

---

* The Observatory is indebted to Simeon Borden, Esq. for this application of the endless screw.

To fulfil the required conditions, the radius of curvature of each rail was made nearly equal to the radius of the circle described by the eye-piece of the telescope. The centre of curvature of the front rail is placed, relatively to the centre of motion of the telescope, as the eye of the observer is to the centre *k*, Fig. 7, the upper part of the rail being carried back far enough not to interfere with the motions of the telescope. The centre of curvature of the back rail is placed, relatively to the centre of the front rail, as the centre *u u* is to the centre *k*. The geometrical principle made use of may be illustrated by describing three circles of equal radii from the apices of any triangle *a b c*, as centres; the relative positions of *a*, *b*, and *c* being those of the observer's eye and the centres *k* and *u u*.

Fig. 12.

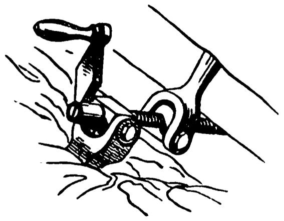


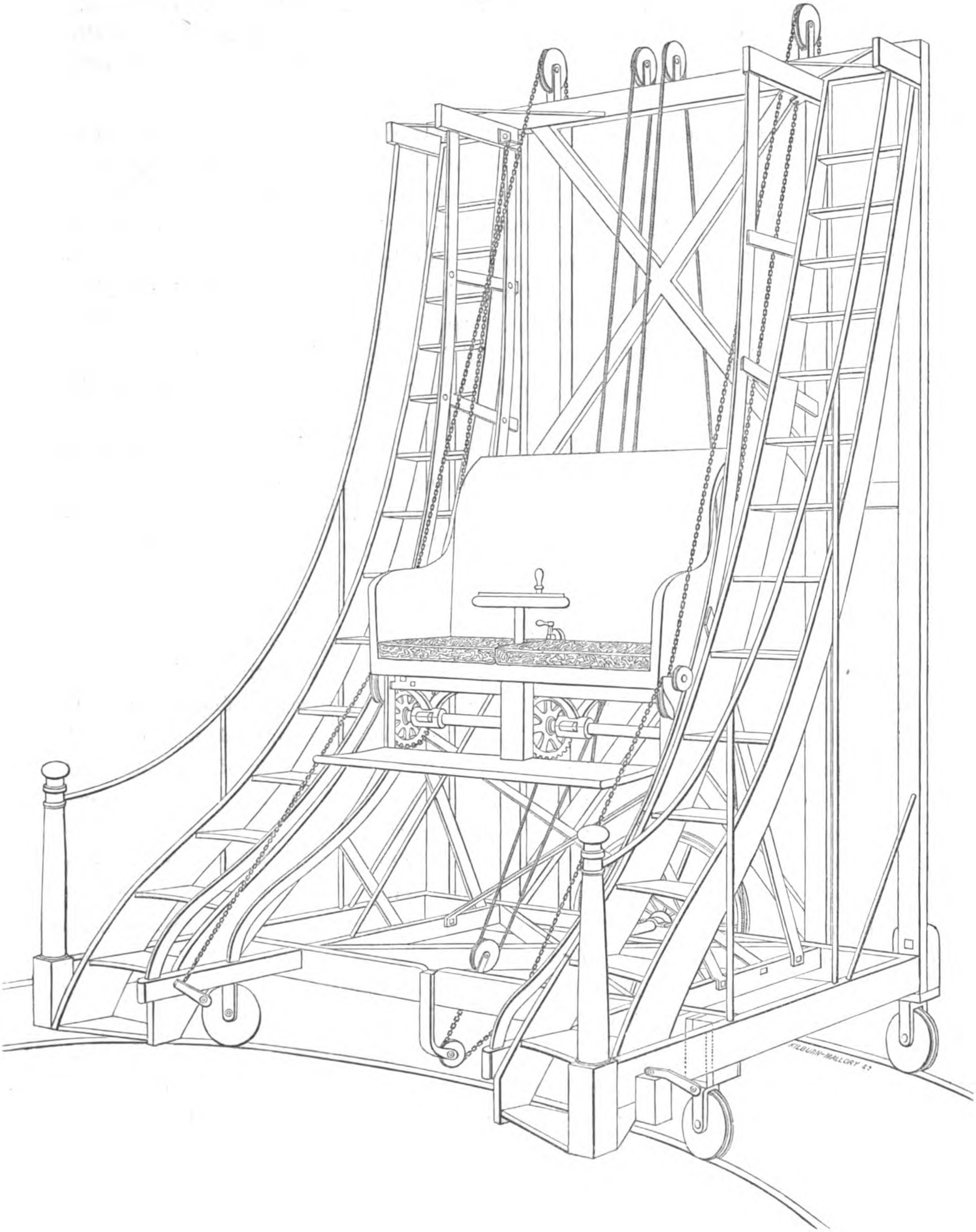
Fig. 12 shows the arrangement for adjusting the position of the back part of the chair for supporting the head.

Attached to the chair at *x*, Fig. 7, is a long box with compartments for holding the different eye-pieces belonging to the telescope.

To facilitate the horizontal movement of the chair, a circular railway is laid on the floor of the dome. The rails are of round iron, one inch in thickness, firmly fastened to the floor by screws. The inner track is laid to the radius of seven feet four inches, and the outer one to twelve feet four inches. On these rails the frame and chair move, on four wheels, having grooves adapted to the rail. A driving wheel, three feet in diameter, is placed at the back part of the frame, and is made to bear with considerable force on the outer track. It has a double groove, one of which fits closely to the rail, and has precisely the action of the driving-wheels of a railway engine; the other is provided with spurs, to prevent the slipping of a rope which passes round it, and leads over pulleys fastened to the top rail of the frame, whence the rope passes down within reach of the observer, when he is seated in the chair, and to a pulley fastened to the lower front rail of the frame. This pulley is attached to the foot of the frame by a spiral spring, for the purpose of maintaining an equable tension of the rope.

This arrangement enables the observer to move himself and the chair round on the railway without rising from his seat, while at the same time he can adjust his position in altitude. Whatever may be the direction in which the telescope is pointed, a proper management of the driving-wheel and endless screw will bring the observer's eye to

Fig. 13.



the most convenient position for observing. The machinery above described is found on trial to fulfil perfectly the objects for which it was designed, giving the observer entire command over his position, while it combines security with ease and steadiness of motion.

The meridian shutters of the transit-rooms are opened and closed by a sliding motion, and are worked by a crank and pulley arrangement connected by ropes.

### *The Great Refracting Telescope.*

If we may credit the declaration of its makers, Messrs. Merz and Mahler of Munich in Bavaria, this instrument is the most perfect of its kind that the art of man has ever produced. Its only rival is the Great Refractor of the Imperial Central Observatory of Russia.

The extreme diameter of the object-glass of the telescope is fifteen and a half English inches; the effective aperture is fourteen and ninety-five hundredths inches; the solar focus is twenty-two feet and six inches. The distance from the outer surface of the object-glass to the point of intersection of the declination and polar axes, is thirteen feet seven inches. From the same point to the solar focus of the object-glass, it is eight feet eleven inches.

The centre of motion of the telescope is twelve feet nine inches above the floor of the dome. The *polar axis* of the instrument is of steel; its length, from the end-bearing of its lower pivot to its junction with the bed of the declination-axis, is three feet ten inches, and its bearings are two feet eight inches apart. The friction on the upper bearing of the axis is relieved by two friction-rollers, seven inches in diameter, attached to the short arm of a lever, which moves on a steel pin passing through it below the axle. The longer arm of the lever passes through the upright part of the cradle, and supports at a forked extremity a powerful balance-weight, which may be so adjusted as to transfer more or less of the superincumbent weight of the telescope and its appendages from the Y support to the rollers. The lower or southern end of the polar axis rests against a plate of gun-metal, which is susceptible of adjustment by means of a stout capstan-headed screw. The hour or right-ascension circle is eighteen inches in diameter, and reads by two verniers to single seconds of time. The cradle in which the polar axis rests is of brass, four feet ten inches in length by nine inches in breadth, and is four inches deep. This cradle is secured to the brass bed-plate by twelve large steel screws. The bed-plate itself is attached to the stone support by six screw-bolts passing through the plate, and through holes drilled into the stone to the depth of five inches, where they enter recesses worked out at the sides for the admission of strong screw-nuts, which are turned on to the ends of the bolts, binding the bed-plate to the stone.

The declination-axis is also of steel, and measures, from its junction with the tube of the telescope, six feet; its bearings are three feet eight inches apart, and are relieved of friction by four friction-wheels, three and a half inches in diameter. The declination-circle is twenty-six inches in diameter, reading by four verniers to four seconds of arc.

The tube of the telescope is composed of light wood and paper, strengthened by iron diaphragms, and covered on the outside by a veneering of mahogany.

The flexure of the tube is counteracted, and its balance preserved, by two round conical brass rods, seventeen feet in length, having at the extremities nearest the eye-end of the telescope brass spherical weights, eight inches in diameter. These rods move on a universal joint near the middle or centre of motion, and the weights oppose the influence of gravitation on the longer and heavier portion of the tube, in every position.

There is a finder telescope attached, of forty-five inches' focus and three inches' aperture. Sidereal motion is communicated by means of clock-work, regulated partly by the action of centrifugal balls, and partly by friction.

There are eighteen different eye-pieces, of the following description, the powers having been determined by the aid of a Dolland dynameter, with various apertures: —

*Annular Micrometers.*

| | | |
|---|---|---|
| No. 1 | Power, . . | 103 |
| 2 | “ . . | 172 |
| 3 | “ . . | 229 |
| 4 | “ . . | 373 |

*Plain Eye-pieces.*

| | | |
|---|---|---|
| No. 1 | Power, . . | 222 |
| 2 | “ . . | 333 |
| 3 | “ . . | 505 |
| 4 | “ . . | 767 |
| 5 | “ . . | 1118 |

*Spider-Line Micrometers.*

| | | | | |
|---|---|---|---|---|
| No. 1 | Power, . . . | 141 | Field of view, . . | 12′ |
| 2 | “ . . . | 206 | “ “ . . . | 9 |
| 3 | “ . . . | 316 | “ “ . . | 7 |
| 4 | “ . . . | 401 | “ “ . . . | 4 |
| 5 | “ . . . | 688 | “ “ . . | 3 |
| 6 | “ . . . | 861 | “ “ . . . | 2 |
| 7 | “ . . . | 1243 | “ “ . . | 2 |
| 8 | “ . . . | 1561 | “ “ . . . | 1 |
| 9 | “ . . . | 2004 | “ “ . . | 1 |

The position-circle of the micrometer at the divisions is seven inches in diameter, reading by two verniers to single minutes. The head of the micrometer-screw is divided into one hundred parts, each part being of the value of one tenth of a second of arc, nearly. The equality of the values of the revolutions and semi-revolutions of the screw has been examined under different temperatures over a space of fifty revolutions. By Polaris the revolutions in different parts of the screw are found to be sensibly equal, and no irregularities were detected beyond the limit of errors to which the determination was liable.

The values of a revolution of the screw, for different temperatures, are as follows:—

Temperature Fahrenheit, $\overset{\circ}{0}$, value of $r = 9.771$
" " +16, " " = .797
" " +61, " " = .801
" " +82, " " = .813

Final value of one revolution,

$$r = 9''.800 + 0''.00026\ (1^\circ - 50^\circ).$$

The dilatation of the screw seems to have greater effect on the value $r$ than the increase of focal distance arising from the expansion of the object-glass.

The workmanship of the machinery is creditable to the makers, and the general plan of the instrument combines strength with simplicity and convenience of management. The friction of the various actions is greatly relieved by the judicious management of counterpoises and friction-rollers, so that the whole, weighing some two or three tons, may be moved with great ease.

It has been objected to the German form of mounting a telescope equatorially, that it requires reversal whenever the object under examination crosses the meridian. This is felt as a practical inconvenience with the Cambridge Equatorial only in small zenith-distances, since in most instances the telescope passes the meridian by more than an hour of right ascension without interference, and always by more than two hours in southern declination.

There are, however, one or two points in which the instrument is susceptible of improvement. The arrangements of the divisions of both the declination and hour circles are awkward, and the reading off of both attended with needless trouble; the screw for adjusting the focus of the eye-pieces is inconveniently situated; and the clock for regulating the movement of the telescope is disproportional to the other parts of the instrument, and too feeble, rendering it in cold weather nearly useless.

In every other particular, there is sufficient reason to be perfectly satisfied with the instrument. The object-glass, by far the most important part, is an admirable specimen of the skill of Messrs. Merz and Son. Its defining excellence is such, that powers of from seven to twelve hundred are habitually used in the measurement of double stars; on rare occasions a power of two thousand may be used to advantage. With this power, the telescope has shown well the discs of Neptune, and of the satellites of Jupiter. With powers of seven or eight hundred, the stars are shown round and small, and stars are perfectly separated whose measured distance has proved to be three tenths of a second of arc. With a power of one hundred and forty, the *sixth* star of the trapezium of Orion is distinctly separated from its bright companion, and the fifth star has been seen after sunrise; this star is classed as of the thirteenth magnitude. The satellite of Neptune, and the inner and eighth satellite of Saturn, are seen steadily, as well as the edge of the ring of Saturn, broken into points and masses of light, at the time when it is commonly said to disappear. The smallness of the discs of the stars, as presented by this telescope, is an indication of its excellence.

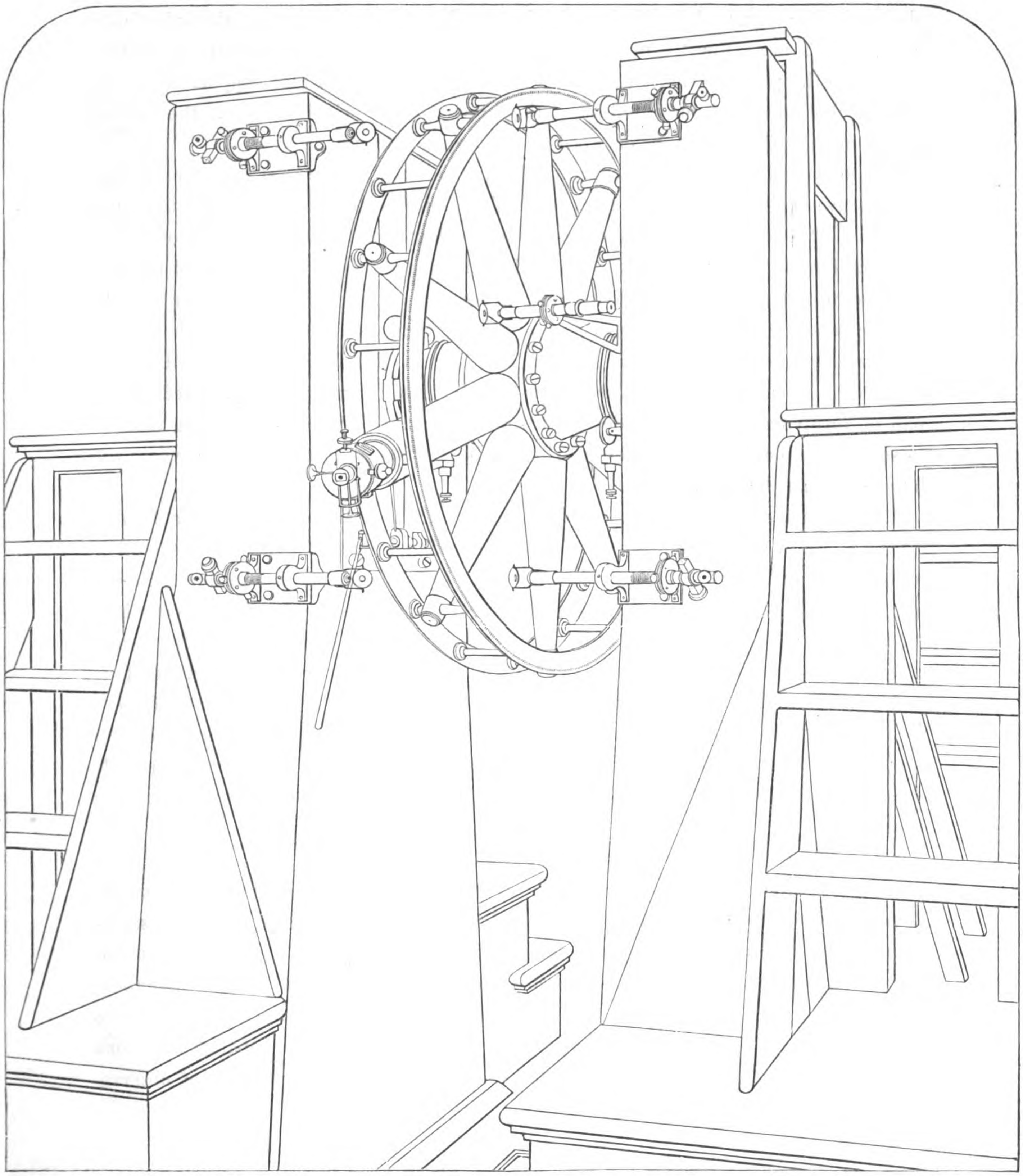
Soon after mounting it, several caps were made for reducing the aperture of the object-glass; these have since been entirely discarded, or they are used only for a different purpose, it having been found on trial that the whole aperture may be used without injury to the definition whenever the condition of the atmosphere is such as to render it worth while to observe at all.

## *The Transit-Circle.*

This meridian instrument was made by Mr. William Simms, of the company of Troughton and Simms of London. In general arrangement it resembles the circle designed and made by Edward Troughton for the Imperial Academy of St. Petersburg, but which, owing to the disturbed state of Russia in 1812, fell ultimately into the hands of Mr. Groombridge, and was mounted at his Observatory on Black Heath, where, under his able management, it rendered for several years most important services to astronomy. Many improvements have been introduced into the Cambridge Circle.

The Cambridge Circle (Fig. 14) is four feet in diameter, the telescope of five feet focus, the object-glass of four inches and a quarter aperture. There are eight reading microscopes, which are directly attached to the stone pier supporting the instrument. Beside the usual provision for illuminating the field through the axis, there is an arrangement for illuminating the wires on a dark field. The eye-piece is provided with two micrometers, one having a motion in right ascension, and the other in declination. The pressure on the pivots is relieved by double friction-wheels, resting upon spiral springs. The circle is divided into five-minute spaces, and the micrometer head has sixty divisions, each division being nearly equal to one second of arc, and may be read by estimation to two tenths of a second. The length of the axis between the shoulders of the pivots is two feet two inches. The pivots are of steel, and two and a half inches in diameter; the bearing-plates of the Y's are eight inches broad and twelve long;

Fig. 14.



they are secured to the granite piers by screws passing into nuts firmly imbedded with plaster in the stone. The friction-wheels for relieving the pressure of the axis pivots upon the Y's are supported by brass plates, eleven inches and a half by twelve inches, secured to the piers in the same manner as the Y plates; they also support the screw of slow motion acting on a tail-piece, the upper part of which embraces the axis in such a manner that it may be clamped or released at pleasure.

The forty-six-inch transit-instrument, which is mounted in the west transit-room, has twenty-seven spider-lines; these lines are in five groups of five lines each, and two lines outside. This arrangement is more particularly adapted to the determination of differences of longitude by the electric method, and this instrument has been used for that purpose in preference to the transit-circle, on account of its admitting of more expeditious reversal; the United States Coast Survey regulations requiring, at each station, the alternate observation of stars near the zenith, with illumination east, and illumination west. In addition to the usual striding-level, this instrument is provided with a pair of revolving tube-levels, a device of Professor Sears C. Walker, intending thereby to supply the place of the striding spirit-level in positions of the instrument where the latter could not be used.

The five-foot equatorial is mounted upon a stone pedestal, supported by a framed octagonal shaft, rising thirty-six feet from the foundation, and insulated from the other parts of the building. The dome is twelve feet in diameter, turning on iron balls, arranged in the same manner as those in the great dome; the opening is two feet wide; the shutters are drawn up by cords, and the dome turned, by the hand, without any machinery to assist the operation. The telescope has a Munich object-glass of four inches and a quarter aperture; it was mounted by Mr. Simms, in the German manner; the right-ascension circle reads to seconds of time, and the declination circle to thirty seconds of arc, and it is furnished with annular and spider-line micrometers. It is used principally for observations of the solar spots, eclipses, and occultations of stars by the moon.

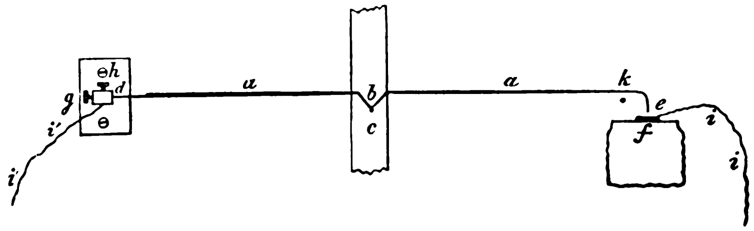
The west wing of the Observatory was planned with more especial reference to a Library, and the continuous observation of terrestrial magnetism and meteorology. Experience has however indicated, that, to be useful in the highest degree, observations of this kind must be obtained by self-registering instruments, and the numerical reductions performed by calculating machines, or an equivalent; otherwise, the expenditure of bodily and mental labor, and the accumulation of figures, are too enormous to be prudently undertaken with limited means. That the requisite apparatus will one day be supplied, is very probable. In the mean while the ordinary course of observation is pursued.

## *Description of the Electro-recording Apparatus.*

The application of electro-magnetism to the purposes of astronomical observation has already been alluded to. The following description, together with the diagrams which accompany it, will show the manner in which the apparatus is arranged at this Observatory, as well as the method pursued in using it.

From one pole of a galvanic battery an insulated copper wire is extended to the two transit instruments, to both of the equatorials, to the prime-vertical transit, the sidereal clock, and the recording machine, where it is connected with the wire of an electro-armature magnet. It is thence carried forward and attached to the other pole of the battery, forming a complete circuit without ground connection. A break-circuit key is placed on the wire at each instrument, within convenient reach of the observer. The galvanic current is momentarily interrupted by the action of the clock at every second of time. This interruption of the galvanic current was originally effected by insulating certain portions of the escapement of the clock; but during the last two years we have adopted the following method.

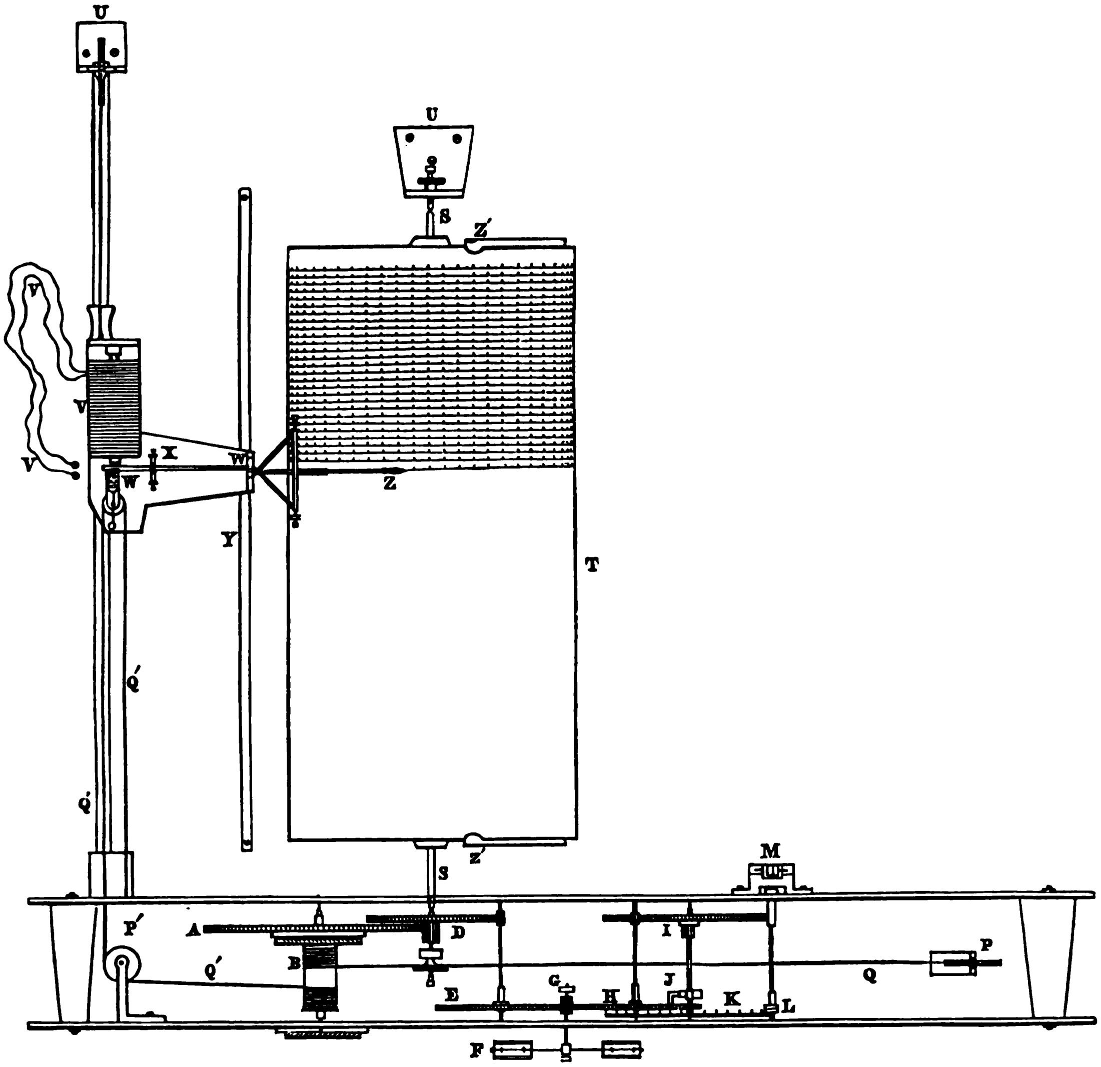
Fig. 15.



In Fig. 15, at *a a*, is shown a steel spring, six inches in length, terminating at *e* in a platinum point. This spring is bent at *b*, so as to form a double inclined plane, the angle at *c* being eighty degrees nearly. One end of this spring is secured to a plate which is screwed fast to the back-board of the sidereal clock. At *b* is shown a portion of the pendulum-rod, in which a gold pin, *c*, is secured in such a position as to act delicately upon the inclined planes of the spring when the pendulum is in motion, thereby raising the point *e*, and detaching it from the mercury contained in the cup *f*, at each vibration. It will be noticed that, when the pendulum is removed a little distance from the vertical position, the platinum point will dip into the quicksilver, and the spring then rest upon the support *k*, placed below it. The repetitions of the armature beats of the magnet are brought to coincidence with those of the clock, by means of the screw *g*, and by raising or depressing the support *k*. The galvanic connection is formed, first, by immersing one end of the main conducting-wire, *i i*, in the quicksilver at *f*; the current then flows through the quicksilver and spring to the block *h*, thence through the other portion of the main conducting-wire, *i' i'*, which is also fastened to *h*, and thence to the other pole of the battery, in its passage charging the electro-magnet shown at V, in Fig. 16.

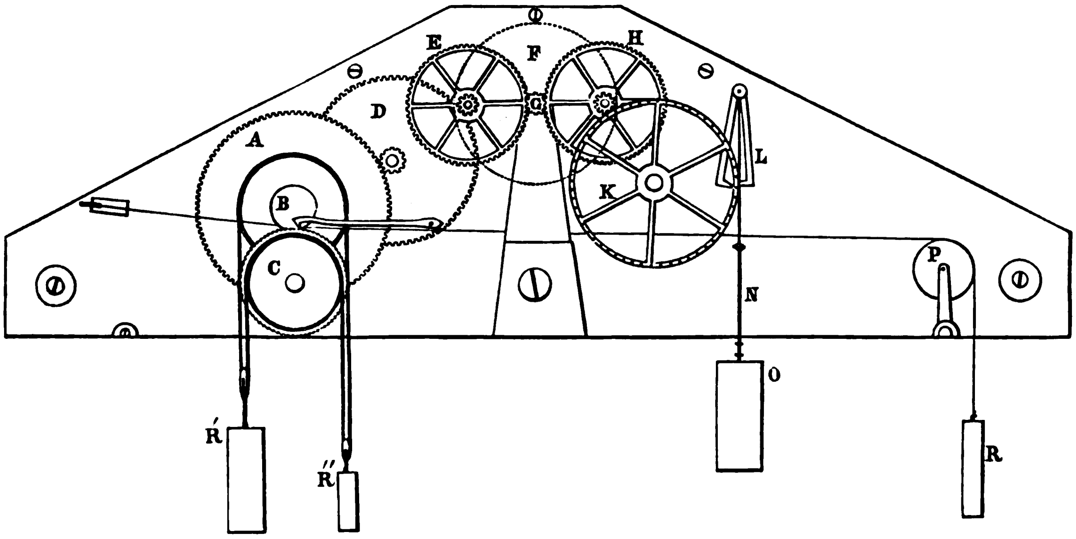
We will now proceed to describe the mechanism by means of which the seconds of the clock are duly registered; and in doing this it will be necessary to refer to Figures 16, 17, and 18. Fig. 16 is a representation of the machine as seen from above; Fig. 17 exhibits a vertical section; the lettering in both of these diagrams refers to the same parts. In Fig. 18 the machine is seen in perspective; this will aid in explaining certain actions and positions that could not be represented in the other engravings, Figs. 16 and 17. The frame plates are of brass, twenty-two inches in length, and seven inches in height at the middle part. These plates are held in po-

Fig. 16.



sition by six pillars, secured to the plates by stout steel screws on both sides of the frame. In Fig. 16, at A, is seen the main wheel; at B, the barrel around which the cord Q is wound on the side next to the wheel, and the cord Q′ Q′ on the part next to the front plate. The use of these cords will be explained farther on. At D is the second wheel with its pinion; the arbor of this wheel carries the cylinder T. At E is shown the third wheel with its pinion, connecting with the fly-pinion at G. At F are seen the fly and its interior bridge; the corresponding bridge could not be well represented on this plate; it may be seen in Fig. 17. The fourth wheel and its pinion are seen at H; this wheel is driven by the fly-pinion. The arbor of the fifth wheel, I, is loosely fitted to the escapement wheel, K, which is propelled forward by means of a connecting spring, one end of this spring being secured to the arbor of the fifth wheel, while the other end presses against a piece projecting from near the centre of the escapement wheel. The motion of these two wheels being concentric, the pressure may be continuous. As originally constructed, both ends of this impulse spring were secured, one to the wheel I, and the other to the escapement wheel; but it was subsequently ascertained that the detached form admitted of a nicer adjustment, while at the same time it was not so liable to be broken, or put out of its proper form, by any sudden force accidentally applied to the wheels.

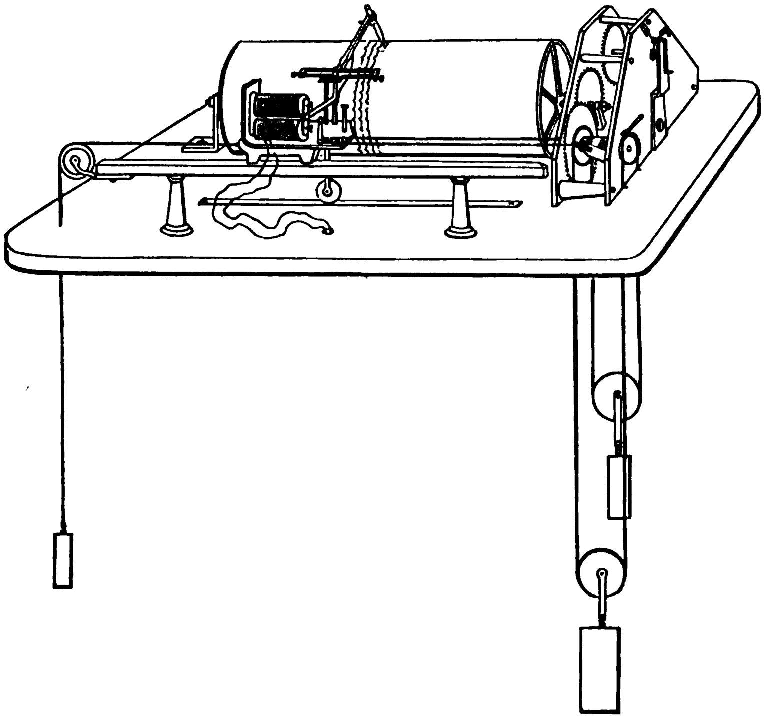
Fig. 17.



In the first construction, the arrangement of the train was such as to require that all the wheels both to the right and left hand of the fly should be *drivers*, and there were two additional wheels, and a double motive force; these, by subsequent improvements, have been reduced in such a manner as to require only a single weight of half the power. This weight, R′, seen in Fig. 17, is suspended by a cord, which, after passing half round a single grooved barrel, which is fastened to the main wheel, A, leads through a pulley supporting the balance-weight R″, and upward over the ratchet-wheel C, and then round the pulley which supports the principal weight, R′. This arrangement of the winding precludes, as is well known, the necessity of introducing a maintaining power.

The armature-magnet V, Fig. 16, is drawn along on the edge of a steel bar extending from U to P,′ parallel to the axis of the cylinder T, by means of a small silken cord, Q′ Q′, one end of which is fastened to the plate frame, and, passing round a pulley attached to the chair of the armature-magnet, is brought to the pulley P′, and thence to the barrel B, which in turning with the main wheel winds up the cord Q′, drawing the magnet and pen towards P′. This action, when combined with the motion of the cylinder T, causes the pen Z to describe a spiral line on the paper covering the cylinder. In the act of re-winding, or rather of drawing back the chair of the magnet to its original station near U, at the end of the steel bar, the barrel will turn freely in that direction on the arbor of the main wheel, and be retained in place by detents and ratchet-work provided for that purpose. The diameter of the barrel B is proportioned to the length of the cylinder T, and the required number of turns. At W W′ is shown the bed-plate of the magnet with its armature, operating the pen at Z. At W is a concentric spiral spring; the use of this is to draw back the armature, at the moment

Fig. 18.



when it is released from the magnet by the interruption of the galvanic current. The bar, extending from the armature to the pen, has a horizontal motion on a centre at W′, and the pen is allowed a vertical motion acting on centres at the forked extremities of the arm. The pressure of the pen upon the paper is regulated by a spring situated below the arm; the pressure of the magnet chair in front is borne by a roller; this is best seen in Fig. 18. At X are opposing screws for adjusting the distance of the armature from the magnet, as well as its amount of action. V V are the wires connecting the magnet with the main circuit.

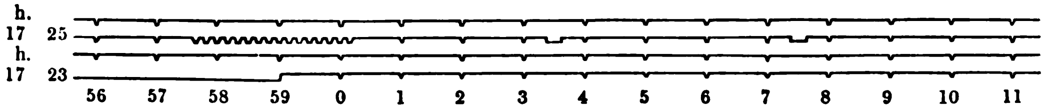
The small weight R, whose cord, Q, passes over the pulley P, and is wound about the barrel B, Figs. 16 and 17, and also the one attached to the magnet V by a cord passing over the pulley near the end, U, of the steel bar, may be seen in Fig. 18; they are balance-weights intended for steadying the motion of the chair on the rail. At Z′ Z′ are spring clasps fastened to the ends of the cylinder T, for the purpose of securing the paper in place. The diameter of the cylinder is six inches, and its length thirteen inches. The escapement is a dead beat, and the pendulum vibrates half-seconds. A *make*-circuit key is placed near the clock. The remaining portions of the machinery are too plainly represented in the engravings to need further explanation; we will therefore proceed to describe the process of using it.

The machine is wound up by pulling downward on the cord to the left hand of the ratchet-wheel C; this ratchet turns on a steel stud screwed into the front plate, and is held from running back by a spring detent, seen above it in Fig. 17. A sheet of thin paper, twelve and a half inches by twenty inches, is wrapped round the cylinder, and is secured to it by the spring-clasps, Z′ Z′. The glass pen at Z is filled with coloring fluid. The pendulum is first put in motion, and then the fly is released by moving a detent spring, not shown in either of the engravings; it is, however, fastened to the front bridge. It will now be understood that the pen will trace a uniform spiral line upon the sheet of paper; but on closing the *make*-circuit key the pen will immediately commence marking a series of offsets at intervals of a second. These offsets are made when the clock breaks the galvanic circuit by lifting the point *e*, Fig. 15, clear of the quicksilver at *f*, and the spiral spring draws back the armature W, giving to the pen a motion in the opposite direction. On the restoration of the galvanic circuit, the armature will be drawn up to the magnet, and the pen will be restored in line; all this may be performed almost instantaneously, but the duration can be varied at pleasure. Practically, we have found a little less than the tenth part of a second to be a convenient quantity.

Thus far, the way in which the seconds of the clock have been indiscriminately recorded has been shown; but it is necessary that the hour, minute, and second, as well as the fractional parts of a second, should be known, and also the interpolated times of observation. This is effected in the following manner. But to explain the process clearly, it seems necessary to recapitulate a little.

It has already been intimated, that the conducting wire traverses the different apartments of the Observatory, passing near the instruments, and is connected with the electro-magnet which operates the recording pen; and that on this wire, besides the *break*-circuit keys placed at each of the instruments, there is a *make*-circuit key stationed near the sidereal clock. When preparing for an observation with the machine already in motion, the circuit is at first opened by means of the last-mentioned key, during perhaps half a minute, and then, *immediately after* the clock has beat the fifty-ninth second, the circuit is closed by this same key. The first recorded second will then be 0 seconds, or the even minute by the clock; a memorandum is then made of the minute and hour, and when the observations are completed, these are transferred to the left-hand margin of the paper. Should any doubt be entertained in regard to the correctness of the first closing of the circuit, the operation is easily repeated for any of the subsequent minutes, without any danger of losing the sequence of the seconds; indeed, it is our constant practice to do so at the termination of each group of observations. In regard to reading off the observations from the sheet, when it is taken from the cylinder, it is done in the following manner. As the cylinder makes one revolution in a minute, each horizontal line represents a minute. The vertical columns represent seconds, counting the seconds from left to right. All that has to be done is to mark the zero column of seconds, and write the hour and minute opposite the appropriate line on the left-hand margin, recollecting that the order of the minutes is from the bottom of the page towards the top. A scale with corresponding division-marks of the seconds is laid on the paper parallel with the minute lines, and the zero on the scale is brought to coincide with that of the record. The hour, minute, second, and decimal part of the second, may then be very readily distinguished by the eye to the tenth of a second, and, when necessary, the hundredth parts may be read off by using a lens and a finely divided scale. As the reading scale is made double the length of the minute line, it is of small importance where the minute commences, provided that the minute which may be in progress at the beginning of the line is correctly marked.

Fig. 19.



The annexed diagram, Fig. 19, has been engraved from an original record, and exhibits the manner in which two wires of an equatorial star were recorded, and the sheet prepared for reading off. It will be seen that in this specimen the twenty-fourth minute of the clock-time commences at the fifth second from the beginning of the line; but $23^{m.}$ is marked on the left-hand margin, and this was done for the reason that the twenty-third minute was then in progress. The close succession of offsets shown on the third line of the diagram was occasioned by the observer's having made a number of taps on his break-circuit key in rapid succession; this was intended to indicate that the star was approaching the system of wires of the instrument. At the instant when the star appeared to be bisected by the first wire, he made a single tap; this is shown by the prolonged offset; and this operation is repeated at each wire.

In observing by the electric method, an equatorial interval of four seconds between the wires has been found convenient. When an observation has been completed, the observer affixes his signature to it by means of the same apparatus which enabled him to record the transit of the star. The evidence of the degree of accuracy which may be obtained by the use of this method will be included in the discussion of the observations.

In the Appendix, containing the Reports of the Committees on the Observatory to the Board of Overseers, together with accompanying documents, published by direction of the Corporation of Harvard College, will be found repeated allusions to the progress of improvement in this method of recording astronomical observations.

# APPENDIX.

# APPENDIX.

---

## I.

## STATUTES OF THE OBSERVATORY.

### I.

THE Observatory at Cambridge, having been erected and furnished with instruments in great part from funds raised by the voluntary subscriptions of individuals and corporate bodies in Boston and its vicinity, and vested by them in the President and Fellows of Harvard College, shall bear the name of THE ASTRONOMICAL OBSERVATORY OF HARVARD COLLEGE.

### II.

The objects of the Observatory are, to furnish accurate and systematic observations of the heavenly bodies for the advancement of Astronomical Science, to co-operate in Geodetical and Nautical Surveys, in Meteorological and Magnetical Investigations, to contribute to the improvement of Tables useful in Navigation, and, in general, to promote the progress of knowledge in Astronomy and the kindred sciences.

### III.

The Director, and one or more Assistants, shall be appointed by the President and Fellows of Harvard College, and be approved by the Overseers. They shall be subject to removal for neglect, for inability to perform their appropriate duties, or for any other just and sufficient cause. The President of the University, together with the Director and his Assistant, or Assistants, appointed as above directed, shall constitute the Faculty of the Observatory, having the same general duties and powers which belong to the Faculties of the other Departments of the University.

## IV.

It shall be the duty of the Director to watch for the phenomena of the heavens, and especially to direct his attention to such as may be available for promoting the advancement of the science of Astronomy, the art of Navigation, the theories of Light and of Vision, and to all new discoveries which may be made by astronomical observers at other stations in our own country, or in any other quarter of the world. In executing this duty he will adopt such a system and pursue such a course of observations as he may deem best suited to accomplish the objects herein enumerated, subject to the approval and control of the President and Fellows.

## V.

The Director shall report annually an account of the operations at the Observatory during the year preceding, and of the condition of the buildings, grounds, instruments, and library. And he shall also make special reports upon such subjects connected with the Observatory as the President and Fellows may indicate, and at such times as they may require.

## VI.

The Director of the Observatory for the time being shall have the right of occupation of the dwelling-house and Observatory, and of all the buildings and adjoining grounds connected therewith, and the care of the same; subject always to the direction and control of the said President and Fellows.

## VII.

The salaries of the Director and Assistants shall be fixed by the President and Fellows, and be paid out of the income of the fund established for this object by the will of the late Edward Bromfield Phillips. From the income of this same fund shall be drawn such sum as, in the judgment of the President and Fellows, shall be necessary or expedient for the purchase of books and instruments, and for their repairs and preservation; and a full account of the expenditure of any sum intrusted from time to time to the Director, for these or other purposes, shall be rendered by him semiannually to the Treasurer of Harvard College. The names of the instruments, and the titles of the books, so purchased, shall be entered in a catalogue or catalogues which shall be kept in the Observatory under the care of the Director.

## VIII.

An accurate record of all the observations, transcribed from the original minutes, and of the reductions and computations made from them, shall be kept in the Observatory; and as far as practicable, this record, or transcript, shall be complete at the end of each calendar year. The Director shall be responsible for the accuracy of this record. All the original minutes shall be carefully preserved.

## IX.

The minutes and the records of the observations shall be under the especial charge of the Director, who will exercise his discretion in allowing other persons to copy or use them; but they shall be always the property of the President and Fellows, and subject to their control.

## X.

The observations shall be prepared for publication by the Director, or under his supervision. The materials to be published, and the time, manner, and style of publication, shall be approved by the President; and all the observations designed for the public shall be first published in Cambridge or Boston, unless by the President's consent some other place shall be selected.

## XI.

It shall be the duty of the Director, as occasion may arise, to correspond with the Directors or Superintendents of other Observatories in America or foreign countries, and to exchange with them his published observations for theirs, with the view, by reciprocal courtesy and aid, to promote the general progress of Astronomical Science, and to add to the collection and value of the Astronomical Library; and copies of letters or papers transmitted, and the originals of those received, shall be preserved in the Observatory.

## II.

## REGULATIONS FOR PUBLISHING THE OBSERVATIONS MADE AT THE OBSERVATORY OF HARVARD COLLEGE.

### I.

THE main object of the Observatory being to advance and diffuse the knowledge of Astronomy, and of other sciences intimately connected therewith, it is requisite that suitable provision should be made for publishing the Observations, and the Director's Annual Reports, either wholly or in part.

### II.

To defray the expenses of such publication the Treasurer of the College is authorized to appropriate annually a sum not exceeding the whole available income of the *Quincy Fund*, according to the understood wishes and intentions of the founder thereof.

### III.

The publication shall be entitled, ANNALS OF THE ASTRONOMICAL OBSERVATORY OF HARVARD COLLEGE; the volumes, or parts of volumes, shall be uniform in size, quality of the paper, and style of execution, and the title-page of each volume shall bear an inscription indicating from what source the means of printing it were derived.

### IV.

The contracts with the printers, binders, engravers, and publishers, and the superintendence of the work while in the press, and of its distribution and sale, shall devolve on the Director of the Observatory, who shall annually render to the Treasurer of the College an account of the expenditures for the same, with the vouchers, and of the manner in which the copies have been disposed of, and of the number he has on hand. The contracts for publishing the work, the quality of the paper, printing, engraving, and the style of execution, shall be satisfactory to the President.

### V.

The Director shall annually pay to the Treasurer the amount received for the sale of the work, provided for and published as aforesaid, which shall by him be credited to the Quincy Fund. Any engraved or stereotype plates used for the work shall be held in custody of the Treasurer, or of the Director at the Observatory.

### VI.

It shall be the duty of the Director, as soon as practicable after the publication of a volume, to cause copies of the same to be transmitted to the several Observatories in America and foreign countries, to such scientific societies of note in various parts of the world as publish their transactions, and to individuals eminent for science, or distinguished friends and benefactors of the Observatory; and he shall keep a record of the same in the Observatory.

### VII.

To each volume received in exchange for the copies provided for and distributed as aforesaid, shall be affixed a label or book-mark, certifying that the College is indebted for it to the Quincy Fund, and all such books shall be deposited in the Library of the Observatory.

## III.

### NAMES OF CONTRIBUTORS TO THE OBSERVATORY.

### 1839.

| | | | |
|---|---|---|---|
| John Quincy Adams, | $ 100.00 | John C. Gray, | $ 100.00 |
| Nathan Appleton, | 100.00 | Abbott Lawrence, | 100.00 |
| Samuel Appleton, | 100.00 | Amos Lawrence, | 100.00 |
| William Appleton, | 100.00 | John A. Lowell, | 100.00 |
| Peter C. Brooks, | 100.00 | Joseph Peabody, | 100.00 |
| Benjamin W. Crowninshield, | 100.00 | Thomas H. Perkins, | 100.00 |
| John P. Cushing, | 100.00 | Jonathan Phillips, | 100.00 |
| Samuel A. Eliot, | 100.00 | Stephen C. Phillips, | 100.00 |
| Ebenezer Francis, | 100.00 | Dudley Pickman, | 100.00 |
| Francis C. Gray, | 100.00 | Paschal P. Pope, | 100.00 |

| | | | |
|---|---|---|---|
| William H. Prescott, | $100.00 | Joseph Tilden, | $100.00 |
| Josiah Quincy, | 100.00 | Thomas W. Ward, | 100.00 |
| George C. Shattuck, | 100.00 | John C. Warren, | 100.00 |
| Robert G. Shaw, | 100.00 | John Welles, | 100.00 |
| Nathaniel Silsbee, | 100.00 | Thomas L. Winthrop, | 100.00 |
| The American Academy of Arts and Sciences, | | | 1,000.00 |

## 1843.

| | | | |
|---|---|---|---|
| David Sears, | $5,500.00 | American Insurance Co., | $500.00 |
| Am. Acad. of Arts and Sciences, | 3,000.00 | National Insurance Co., | 500.00 |
| Henry Oxnard, | 100.00 | Washington Insurance Co., | 300.00 |
| George F. Parkman, | 100.00 | Daniel P. Parker, | 100.00 |
| J. M. Forbes, | 25.00 | Henry Plympton, | 50.00 |
| Ozias Goodwin, | 100.00 | Samuel Austin, Jr., | 25.00 |
| Thomas W. Ward, | 200.00 | J. S. Amory, | 25.00 |
| A. E. Belknap, | 25.00 | George H. Kuhn, | 25.00 |
| Merchants' Insurance Co., | 500.00 | Thomas Wetmore, | 10.00 |
| Tremont Insurance Co., | 200.00 | Israel Munson, | 200.00 |
| Equitable Safety Insurance Co., | 250.00 | Francis Bassett, | 25.00 |
| Nathaniel I. Bowditch, | 100.00 | Richard D. Harris, | 100.00 |
| George C. Shattuck, | 500.00 | John C. Gray, | 100.00 |
| Samuel Appleton, | 500.00 | Horace Gray, | 100.00 |
| William J. Walker, | 100.00 | William Lawrence, | 100.00 |
| Neptune Insurance Co., | 300.00 | Ezra Weston and Sons, | 200.00 |
| Massachusetts Humane Society, | 500.00 | William Sturgis, | 100.00 |
| Thomas B. Wales, | 100.00 | Bates and Thaxter, | 50.00 |
| John Ware, | 25.00 | Society for the Diffusion of Useful Knowledge, | 1,000.00 |
| J. I. Bowditch, | 550.00 | Nathaniel Silsbee, | 100.00 |
| William Amory, | 50.00 | Charles Lyman, | 100.00 |
| Martin Brimmer, | 100.00 | J. J. Dixwell, | 50.00 |
| John Quincy Adams, | 100.00 | Thomas B. Curtis, | 50.00 |
| Samuel Fales, | 100.00 | James Davis & Co., | 100.00 |
| Francis C. Gray, | 100.00 | Samuel T. Armstrong, | 25.00 |
| Amos Lawrence, | 200.00 | Israel Whitney, | 25.00 |
| Abbott Lawrence, | 200.00 | George Lyman, | 100.00 |
| Nathan Appleton, | 200.00 | Edmund Dwight, | 100.00 |
| John L. Gardner, | 100.00 | Thomas Lee, | 100.00 |
| George Hallet, | 100.00 | John Welles, | 200.00 |
| C. G. Coffin, Jared Coffin, J. W. Barrett, G. B. Upton, | 300.00 | Samuel C. Gray, | 50.00 |

| | | | |
|---|---|---|---|
| John Parker, | $200.00 | D. Boyden, | $50.00 |
| Joseph Grinnell, | 50.00 | Peter C. Brooks, | 1,000.00 |
| William Pratt, | 200.00 | Francis Tudor, | 50.00 |
| Nathaniel West, | 200.00 | H. Codman, | 50.00 |
| D. L. Pickman, | 200.00 | Robert G. Shaw, | 500.00 |
| N. W. Neal, | 200.00 | John P. Cushing, | 500.00 |
| John Codman, | 100.00 | Joseph Peabody, | 500.00 |
| Theodore Lyman, | 200.00 | Samuel Rodman, | 50.00 |
| J. Chickering, | 25.00 | Francis Parkman, | 100.00 |
| George Howland, | 200.00 | Thomas H. Perkins, | 500.00 |
| Gideon Howland, | 200.00 | Josiah Quincy, | 100.00 |
| John A. Parker, | 200.00 | Jonathan Phillips, | 500.00 |
| William Rotch, Jr., | 200.00 | Charles H. Mills, | 60.00 |
| James Arnold, | 200.00 | J. G. Loring & Co., | 60.00 |
| William Appleton, | 500.00 | William Shimmin, | 100.00 |

### 1846.

| | | | |
|---|---|---|---|
| Francis C. Lowell, | $100.00 | Jonathan Phillips, | $200.00 |
| Ozias Goodwin, | 100.00 | Theodore Lyman, | 200.00 |
| Augustine Heard, | 50.00 | William Sturgis, | 200.00 |
| Ebenezer Chadwick, | 50.00 | Josiah Quincy, Jr., | 100.00 |
| Samuel Appleton, | 200.00 | Thomas H. Perkins, | 200.00 |
| J. I. Bowditch, | 200.00 | Josiah Quincy, | 200.00 |
| Edmund Dwight, | 200.00 | John C. Gray, | 200.00 |
| B. R. Nichols, | 200.00 | John Welles, | 200.00 |
| George C. Shattuck, | 200.00 | William Lawrence, | 200.00 |
| Charles H. Mills, | 150.00 | Nathan Appleton, | 200.00 |
| Peter C. Brooks, | 200.00 | Abbott Lawrence, | 200.00 |
| Francis C. Gray, | 200.00 | John P. Cushing, | 200.00 |
| John A. Lowell, | 200.00 | Thomas B. Wales, | 200.00 |
| Paschal P. Pope, | 100.00 | W. H. Simpson, | 50.00 |
| A. A. Lawrence, | 100.00 | Daniel P. Parker, | 50.00 |
| James Savage, | 100.00 | George Parkman, | 20.00 |
| William Appleton, | 200.00 | | |

### 1847.

| | |
|---|---|
| David Sears, | $5,000.00 |

### 1848.

| | |
|---|---|
| Edward Bromfield Phillips, | $100,000.00 |

## 1851.

| | | | |
|---|---|---|---|
| David Sears, | $100.00 | John Welles, | $100.00 |
| J. I. Bowditch, | 125.00 | J. D. Oxnard, | 50.00 |
| Nathan Appleton, | 100.00 | Charles Amory, | 50.00 |
| Samuel Appleton, | 100.00 | James S. Amory, | 50.00 |
| William Appleton, | 100.00 | William Amory, | 50.00 |
| W. C. Bond, | 125.00 | E. Austin, | 50.00 |
| James Arnold, | 100.00 | S. Austin, | 50.00 |
| Peter C. Brooks, | 100.00 | Daniel C. Bacon, | 50.00 |
| William S. Bullard, | 100.00 | William B. Bacon, | 50.00 |
| J. Davis, Jr., | 100.00 | J. D. Bates, | 50.00 |
| Edward Everett, | 100.00 | Charles Beck, | 50.00 |
| John D. Gardner, | 100.00 | J. Borland, | 50.00 |
| Ozias Goodwin, | 100.00 | Henry Cabot, | 50.00 |
| John L. Gardner, | 100.00 | Ebenezer Chadwick, | 50.00 |
| Abbott Lawrence, | 100.00 | Thomas B. Chadwick, | 50.00 |
| George W. Lyman, | 100.00 | George B. Dixwell, | 50.00 |
| James K. Mills, | 100.00 | J. J. Dixwell, | 50.00 |
| Robert T. Paine, | 100.00 | J. M. Forbes, | 50.00 |
| Francis Peabody, | 100.00 | Augustine Heard, | 50.00 |
| George Peabody, | 100.00 | Henry P. Oxnard, | 50.00 |
| Thomas H. Perkins, | 100.00 | William D. Pickman, | 50.00 |
| Josiah Quincy, Jr., | 100.00 | Josiah Quincy, | 50.00 |
| George C. Shattuck, | 100.00 | Richard S. Rogers, | 50.00 |
| Robert G. Shaw, | 100.00 | William Ropes, | 50.00 |
| M. H. Simpson, | 100.00 | William Sawyer, | 50.00 |
| Jared Sparks, | 100.00 | William Sturgis, | 50.00 |
| John E. Thayer, | 100.00 | William Timmins, | 50.00 |
| Joseph Tilden, | 100.00 | George B. Upton, | 50.00 |
| Thomas B. Wales, | 100.00 | Thomas Wigglesworth, | 50.00 |
| T. W. Ward, | 100.00 | Jonathan P. Hall, | 25.00 |

## 1855.

| | |
|---|---|
| Resulting from the Will of Josiah Quincy, Jr., | $10,000.00 |

## IV.

## Report of the Committee appointed by the Overseers of the University at Cambridge to Examine the Observatory, for the Academic Year 1845-46, with the Accompanying Documents.

By Hon. JOHN QUINCY ADAMS,

CHAIRMAN OF THE COMMITTEE.

---

*Read and Accepted,* 4 *February,* 1847.

---

The Committee appointed by the Board of Overseers of Harvard University, to examine into the condition of the Astronomical Observatory belonging to that Institution, have attended to that duty, and report.

They present to the Honorable Board the following list of papers, exhibiting the condition of this department of the Institution.

1. A letter from the Chairman of the Committee, dated Boston, 19th May, 1845, and addressed to the Hon. Josiah Quincy, then President of the University, Cambridge.

2. A letter from the Hon. Josiah Quincy, dated Cambridge, 5th August, 1845, in answer to the preceding.

To this answer are annexed the following papers: —

A. Extract from the Appendix to Quincy's History of Harvard University, Vol. II. pp. 566-568.

B. A letter, dated Cambridge, 9th June, 1845, from Joseph Lovering, Hollis Professor of Mathematics and Natural Philosophy in Harvard University, to the Hon. Josiah Quincy.

C. Report of a Committee appointed by the Corporation of Harvard College, 18th October, 1839, dated 29th November, 1839, stating an agreement with Mr. Bond, making a temporary provision for the securing his services in the Observatory.

D. Report of a Committee at a special meeting held in Boston, February 12th, 1840, stating a proposition made by a committee of the American Academy of Arts and Sciences, relative to the appropriation of a sum to be applied to the purchase of instruments for magnetic and meteorological observations, with the vote of the Corporation of Harvard University thereupon.

* E. A plan for an Observatory, referred to in the letter of President Quincy to the Chairman of this Committee.

* The papers marked with an asterisk are omitted.

*F. Interrogatories relating to the plan for the Observatory, with the answers thereto.

*G. A description, by Mr. Bond, of equatorial and other instruments for the Observatory.

*H. Data by Mr. W. C. Bond, given in answer to some of the questions contained in the letter of the Chairman of this Committee, 30th May, 1845.

*I. Letter from Mr. Bond, dated Cambridge, 11th June, 1845, to President Quincy, respecting the relative duties of the Astronomical Observer, and of the Perkins Professor of Astronomy.

*K. Duties of the Director of the Observatory.

*L. Duties of the Perkins Professor of Astronomy.

*M. Letter from Professor Peirce, dated Cambridge, 15th June, 1845, to the President of the University.

*N. Letter from Professor Pierce, dated Cambridge, 7th May, 1845, to the President of the University.

O. Letter from Professor Peirce, dated Cambridge, 10th May, 1845, to the President of the University.

P. Two letters from F. Beaufort, Esq., dated Admiralty, London, January 29, and April 4, 1845, to W. C. Bond, Esq., with observations on certain stars, by Professor G. B. Airy, Greenwich Observatory.

*3. List of Instruments, Books, Charts, and other Apparatus, belonging to William Cranch Bond, at the Observatory of Harvard University, 28th November, 1843.

*4. List of Instruments, Books, and Apparatus belonging to the Corporation of Harvard College, at the Observatory, 28th November, 1843.

This series of papers was collected for the preparation of a Report to the Board of Overseers for the year 1845, as was also the annual statement of the Treasurer of the University; the following extract of which was signed to be reported by John Quincy Adams and Abbott Lawrence, being paper appended to this report, marked 5.

On the 9th day of September last, the Committee visited the Observatory, and received from Mr. Peirce, Perkins Professor of Astronomy, and from Mr. W. C. Bond, the Observer, the following reports and papers hereto annexed: —

6. Report of Mr. Peirce, Perkins Professor of Astronomy and Mathematics, to the Committee appointed by the Board of Overseers, 9th September, 1846.

7. Report of Mr. W. C. Bond, Observer, to the same Committee, with the following papers annexed: —

*1st. Notice of Biela's Comet, as seen at the Cambridge Observatory, with a refracting telescope, of two and three quarters inches object-glass, and forty-six inches focus.

* 2d. Moon Culminations observed at Cambridge, Massachusetts, corrected for collimation, level, azimuthal deviation, and clock rate and error.

* 3d. Transit of Mercury, May 8, 1845.

* 4th. Occultations and Eclipses observed at Dorchester, Massachusetts. — Occultations and Eclipses observed at Dorchester and Cambridge.

* 5th. Micrometer Measurements during the Eclipse of May 6, 1845, corrected for refraction. Cambridge Observatory. — Micrometer Measurements during the Eclipse of April 24, 1846. Corrected for refraction, and for the sun's motion in the intervals of transit. Cambridge Observatory.

* 6th. Transit of Stars over the Prime-Vertical, observed at Cambridge with a forty-six-inch transit-instrument.

* 7th. Observations on the Comet of June, 1845, made at the Cambridge Observatory.

* 8th. Meteors.

9th. Copy of a letter from Mr. William Simms, of the company of Troughton and Simms, to Mr. W. C. Bond, dated London, June 18th, referred to in the report of that gentleman.

With these papers was also transmitted an article from the published Memoirs of the American Academy, upon the Latitude of the Cambridge Observatory in Massachusetts, determined from Transits of Stars over the Prime-Vertical, observed in the Months of December, 1844, and January, 1845, by William C. Bond, Major J. D. Graham, and George P. Bond. By Benjamin Peirce, Perkins Professor of Astronomy in Harvard University.

These papers will exhibit to the Board of Overseers a full view of the condition of the Observatory connected with the University at Cambridge, as it was on the 9th of September last, when the Committee last visited that establishment; since that time, on the third day of December, the large refractor imported from Munich has been received, but the mounting of the instrument itself has not yet arrived.

There is also a transit-instrument still to be received from Great Britain, and expected to arrive in the course of the ensuing spring.

These instruments are necessary to complete the apparatus indispensable to facilitate the concurrent labors of the Perkins Professor of Astronomy, and for the Observer for whose support a temporary provision has been made, and for whom a final provision, to give full efficacy to this institution, is yet to be executed.

All which is respectfully submitted.

(Signed,)

JOHN QUINCY ADAMS,
ABBOTT LAWRENCE,
DAVID SEARS,
R. T. PAINE.

*Boston, January* 27, 1847.

## To the Hon. Josiah Quincy, President of Harvard University, Cambridge.

Boston, 19th May, 1845.

My dear Sir: — In our recent conference with you at the Observatory, I expressed the desire that the Committee appointed by the Board of Overseers of the University to report to them on their next annual meeting "*On the Observatory*," should be able to represent, not merely a brief and verbal report of their inspection of the buildings and instruments, and the condition in which they found them, but an account somewhat in detail of the whole establishment, for a permanent enlargement of the capacities of the University as a seminary of learning and of education to the future generations of our Commonwealth. For this purpose it appears to me necessary to include in the report some account of the origin of this establishment itself; of the legal forms by which it has been granted as an endowment of the University; of the expenditures which have hitherto been incurred in the execution of the design, and by what means they have been provided; of the funds which may yet be required to make the establishment most effective for the purposes to which it is to be devoted; and of the prospects of usefulness for the promotion of science which we may be encouraged to expect from it.

In the principal materials for such a report the Committee must be indebted to you; and without intending to aggravate the burden, already so onerous, of your duties, I will merely suggest the principal inquiries upon which they would be glad to receive information, in such form as may be most agreeable and convenient to yourself.

1st. A short narrative of the origin and progress of the undertaking to erect an Astronomical Observatory at Cambridge, for continual observation of the heavens, connected with, and placed under the direction of, the College government.

2d. Accounts of the moneys expended, and of the funds collected for the purchase of the land upon which the Observatory has been erected, and of the instruments and books already procured, or ordered, distinguishing between the amount of the funds of the University appropriated for the establishment, and those obtained from individuals, or associated contributions.

3d. A plan of the land purchased, on which the buildings are erected; of the buildings themselves; of their internal arrangements for the fixture of the several instruments to be employed in observation. A description of the large Fraunhofer Refractor, ordered from Munich, and the conformation of it to the stone pier on which it is to be mounted. A like description of the other instruments, and the conformation of the apartments in the buildings to their fixture for observation.

4th. The appointment of an Observer and one Assistant, a measure indispensable to make the whole establishment effective for the purpose of continuous observation. In the first instance, it is very important and desirable that these offices should be conferred upon Mr. Bond and his son, but as a permanent institution, it seems that provision should be made for a regular succession to these offices. That the mode of their appointment, the occasions of vacancy, the tenure of their offices, their right of occupation and custody of the buildings, both dwelling-house and Observatory, and of the adjoining grounds, should be regulated and prescribed. That the line of division between *the duties* of the Observer, and those of the Perkins Professor of Astronomy and the Mathematics, should be accurately drawn. That the extent to which the Professor shall have a right to the use of the instruments and of access to the Observatory, for the purposes of instruction in his department to the students of the University, should be clearly defined. Whether some liberty of occasionally assisting the Observer in making observations may be indulged to students, whose inclinations may take a special direction to the study of physical astronomy, and whether the teaching of the use of the instruments to all the students of the higher classes may not be included among the joint duties of the Professor and of the Observer.

5th. The regular compensation to be allowed to the Observer, and to the Assistant, in addition to the occupation of the dwelling-house and the grounds. The duties to be required of them, and the remedy for the possible neglect or inability to perform them. The definition of the duties, and the exercise of the power of removal, are points of peculiar delicacy, to be drawn up with care, without reference to any present circumstances or persons.

6th. The fund to be raised by contributions of individuals, — its amount, — the amount which it will be in the power of the Corporation to add to it, to constitute the whole fund, to be duly invested, and from the income of which the salaries of the Observer and Assistant may be permanently provided for, and other expenses to no considerable amount, but occasionally necessary, may be defrayed.

7th. In estimating the amount of money to be raised, it will deserve consideration how, and in what form, a journal record of observation should be kept, and published from time to time. A manuscript report of the journal should be required from the Observer annually, or perhaps quarterly, before the Corporation, and submitted to the standing Committee of the Overseers annually appointed by the Board.

8th. In describing and defining the duties of the Observer, with a general authority, and instruction to watch for all the phenomena of the heavens discernible to the human eye, his special attention should be drawn to such as may be available to promote the advancement of the science of astronomy, the art of navigation, the theories of vision and of light, the construction of mechanical instruments to enlarge the power of the human eye, and all *new* discoveries which may be made by astronomical observers, at other stations in our own country, or in any other quarter of the world.

9th. A list of the books, and of the periodical publications upon the subject of astronomy, in Great Britain, France, Italy, Germany, Spain, Russia, Sweden, Denmark, Norway, or elsewhere, which Professor Peirce or Mr. Bond may deem necessary for the use of the Observatory, is requested of those gentlemen, with an estimate of the cost of procuring them, the periodicals speedily after their publication, and a suggestion of any mode of obtaining them by correspondents at London, Paris, and elsewhere.

10th. I solicit, in behalf of the Committee of the Board of Overseers "on the Observatory," your answer to these inquiries at your earliest convenience. With any other recommendation to *them* which you may deem advisable, for the effective accomplishment of this undertaking to enlarge the sphere of education at our University, of the honor and reputation of our country, and of the glory of God, in the mechanism of the Universe, unfolded in the progressive acquisition of knowledge to the mind of immortal man.

Respectfully and affectionately your friend,

JOHN QUINCY ADAMS.

---

To the Hon. John Quincy Adams.

Cambridge, August 5, 1845.

My dear Sir: — I have reluctantly delayed replying to your letter of the 19th of May last, relative to the Observatory recently established in connection with Harvard University; but engagements incident to the last term of the academic year, and also the nature and variety of details your inquiries included, have made an earlier attention to your request impracticable.

In my reply, I shall follow as nearly the course marked out by those inquiries as is possible; and answer them with as much completeness as the facts and documents I have been able to collect permit.

Concerning the earlier and unsuccessful attempts to found an Observatory in connection with Harvard University on a scale adequate to the greatness and importance of the object, I can add nothing to the statement contained in one of the notes to my History of that seminary (Vol. II. pp. 566–568), a copy of which I here subjoin.

The connection of Mr. William Cranch Bond with the University may be regarded as the first step, efficient in its nature, towards an Observatory at Cambridge, with instruments adequate to important scientific observations. Antecedent to that event, which occurred in 1839, it will appear by Professor Lovering's letter, subjoined (marked B), that the College did not possess a single instrument adapted to make an astronomical observation, "which would have any scientific value," in the present state of the science; the instruments used by Professor Winthrop being antiquated, and of little comparative value. For a specification of the astronomical instruments, at the time alluded to, in its possession, I respectfully refer to that letter.

The origin and first form of Mr. Bond's connection with the seminary were as follows. Early in the year 1839 the President of the University, being informed that Mr. Bond was engaged, under contract, with the government of the United States, in a series of astronomical, meteorological, and magnetic observations at Dorchester, with reference to the Exploring Expedition of the United States, then in the Southern Ocean, it occurred to him, that, if Mr. Bond could be induced to transfer his residence and apparatus to Cambridge, and pursue his observations there, under the auspices of the University, it would have an important influence in clearing the way for an establishment of an efficient Observatory, in connection with that seminary, by the increase of the apparatus at its command, by the interest which the observations making by Mr. Bond were calculated to excite, and, by drawing the attention of the citizens of Boston and its vicinity to the great inadequacy of the means possessed by the University for efficient astronomical observations, create a desire and a disposition to supply them.

The known character of Mr. Bond, the high esteem entertained for him by his fellow-citizens, his unquestionable talent and extraordinary tact for astronomical observations, his zeal and devotedness to that science, all concurred to strengthen the first suggestions relative to the desirableness of effecting a transfer of Mr. Bond and his apparatus to Cambridge.

Accordingly, on the 26th of October, 1839, the President stated these views to the Corporation of the College, who immediately acceded to them, and appointed the President and Mr. Lowell a committee with full authority to make the suggested arrangement with Mr. Bond.

This committee, having effected the object of their appointment, made a report to the Corporation, which, being accepted by them, resulted in the agreement with Mr. Bond, which is subjoined, marked C.

The same committee, being thereto authorized by the Corporation, obtained from thirty gentlemen of Boston and its vicinity, by a subscription of one hundred dollars each, the sum of three thousand dollars, which was applied to making the necessary arrangements to carry into effect this agreement with Mr. Bond; who soon after transferred his residence and apparatus to Cambridge, took possession of the Dana House, and proceeded to pursue his astronomical, meteorological, and magnetic observations there, to the extent which his apparatus, and the pecuniary means possessed by the University applicable to this purpose, would permit.

On the 12th of February, 1840, Mr. Bond was elected by the Corporation Astronomical Observer for the seminary, and subsequently his election was sanctioned by the Board of Overseers. This appointment drew the attention of the public to this subject. The wants of the University in the instruments and means applicable to important scientific observations began to be known and lamented. The American Academy, induced by this connection of Mr. Bond with the University, made a proposition to the Corporation, including an offer from its funds, to be applied under their auspices, and for the use of Mr. Bond, to the purchase of instruments adapted to make magnetic and meteorological observations. This proposition resulted in a vote of the Corporation, including an agreement, subsequently acceded to by the American Academy, which is subjoined, marked D.

The success attending the observations consequent upon this agreement, and the enlarged number and power of the instruments now placed at the disposal of Mr. Bond, increased greatly the interest in the subject in Boston and its vicinity. It soon was apparent that the Dana house was not a satisfactory position to become a permanent site for a great Observatory. The height of the hill on which it was situated was not sufficient. The range of vision from it was liable to be wholly, as it had already been partially, obstructed by buildings in the vicinity. An opinion therefore became general among the friends of astronomical science and of the University, that, if it were intended to make Harvard College the seat of an Observatory adequate to the interests of science and worthy of that institution, a new and a more elevated site must be sought and obtained. Accordingly, the Corporation, on the 4th of September, 1841, on motion of the President, appointed a large committee, consisting of the President, Mr. Lowell, Mr. Ward, Treasurer, and Mr. Farwell, Steward of the College, with full authority to select and purchase a lot of land adapted to such an Observatory as was contemplated. That committee, after examining all the eminences surrounding the plain on which the College is situated, and considering all their respective advantages and disadvantages, finally selected and made purchase of a lot of land belonging to the heirs of the late Andrew Craigie, Esq., and known by the name of "Summer-House Hill," which for its present unobstructed prospect, and its freedom from all liability of having its range of vision obstructed in future, and for its general suitableness for astronomical purposes, is without question unequalled by any other position in Cambridge or its neighborhood. Subsequently, it being deemed expedient for the future interests of the University that the westerly part of "Summer-House Hill" should be obtained for the same use, this also was purchased by the Corporation.

Both these pieces of land cost the College $ 8,300, and, together, contained upwards of twelve acres. That part of these purchases which was peculiarly adapted for the use of an Observatory, the Corporation caused to be fenced off, and appropriated to that object; amounting, in extent of land, to upwards of six acres, and in value, at the rate of the cost of the whole purchase, to four thousand one hundred dollars. A plan of the whole land thus set apart accompanies this report, marked E.

After these purchases, the circumstances of the period rendered it inexpedient for the Corporation to put to the test the liberality of the friends of the science of astronomy and Harvard College; and nothing was done further on the subject until September, 1841, when, on the application of Professors Peirce and Lovering, the Corporation authorized a society to be formed, among students of the three upper classes who were willing to join it, for the purpose of meteorological observations, under the direction of those Professors; and made a small appropriation for fuel, lights, and incidental expenses. By the aid of the Society thus formed, a series of observations were made *for more than a year*, on the barometer, thermometer, and the three magnetic elements, during the whole day and night, at intervals of two hours or half an hour, as other duties rendered it convenient. These observations were carried on with great spirit, and to entire satisfaction. The results have been communicated to the American Academy, and published in its Memoirs; a copy of the Memoirs, at the request of Mr. Lovering, I shall transmit to you with this letter.

In July, 1842, Professor Peirce, having received the appointment of Perkins Professor of Astronomy, memorialized the Corporation on the necessity of procuring a large telescope, equatorially mounted, intimating that he had already the assurance from several liberally disposed gentlemen of subscribing themselves for that object $ 3,500. In consequence of this memorial, the Corporation took measures to ascertain the cost of such an instrument of the largest size; and gave Mr. Bond authority to employ an agent to go to Munich, where it was understood such telescopes were constructed in a manner the most approved by the astronomers of Europe. And also to open a correspondence with several distinguished European astronomers, to obtain their opinion upon the most suitable instruments, and the best manufacturers of them. This Mr. Bond did accordingly, and very attentive and satisfactory answers were received from Professors Airy, Herschel, Robinson, and others.

These measures of the Corporation having been made known to the gentlemen of

Boston and its vicinity interested in astronomical science, several members of the American Academy requested a meeting of gentlemen interested in nautical and astronomical science, on the subject of procuring instruments suitable for observations in astronomy. While this measure was under consideration, on the 29th of March, 1843, David Sears, Esq. addressed a letter to the President of Harvard University, expressing his concurrence in the plan, and offering to place at the disposal of the Corporation five thousand dollars, for the purpose exclusively of being applied to the erection of an Observatory Tower, for astronomical uses, provided the University would, in a reasonable time, increase this sum by such an appropriation as shall in their opinion furnish the Observatory with suitable instruments for its object. Mr. Sears, in making this proffer, acknowledged that one of his prevailing motives was to make Harvard College the location of all funds raised for an Observatory, being desirous that the Observatory established in this vicinity should be placed under the superintendence of that institution. Views at once so generous and gratifying were reciprocated by the Corporation with the promptness and expressions of gratitude they claimed.

Professors Peirce and Bond were consulted, and *twenty thousand dollars* was fixed upon as the amount which ought to be raised by subscription, to fill the condition specified by Mr. Sears. The Corporation immediately commenced the attempt with zeal and spirit, and on the 29th of May ensuing the President had the satisfaction to report to that body that the design had been accomplished, and the twenty thousand dollars required had been subscribed, in addition to the amount offered by Mr. Sears, for a tower.

Suitable acknowledgments were voted by the Corporation to Mr. Sears and the other liberal subscribers; among whom the American Academy, the Society for the Diffusion of Useful Knowledge, the Merchants', American, National, Washington, Neptune, Equitable, and Tremont Insurance Companies, and the Massachusetts Humane Society, were contributors to the amount of $ 7,050, and the remainder was subscribed by private individuals.

Subsequently Mr. Sears added the sum of five hundred dollars to his former subscription, for the object expressed in his former letters, which led the Corporation again suitably to express their grateful sense of this additional bounty. No delay was permitted, after this, to occur in carrying into effect the views and wishes of the beneficent contributors to the Observatory, and the Corporation deemed themselves called upon, by a sense of duty, to meet this noble spirit existing in the community with a corresponding liberal appropriation on their part, to the utmost of their general means. Plans of a building for an Observatory, and the buildings incident to it, were considered, adopted, proposals issued, and both the tower and required buildings have been erected with as much care and economy as the circumstances and the nature of the objects permitted. After long deliberation and consultation, an approved plan for a telescope being determined upon, a contract has been entered into with one of the best recommended manufacturers in Munich, for a telescope of great power, which, it is expected, will be shipped for this country in the course of the ensuing spring. The astronomical, magnetic, and meteorological apparatus which had been erected at the Dana house, has been transferred to the recently established Observatory, of which Mr. Bond and his family are already in possession.

Although the Corporation of the College have done their utmost to meet the wishes and liberal spirit of Boston and its vicinity, it cannot and ought not to be concealed, that they have expended to the extent their sense of duty allows, and it must be understood that the wants unavoidably incident to a great Observatory, such as the spirit and intelligence of the citizens of Boston and its vicinity have a right to require, cannot be supported hereafter, except by an application of the same liberal patronage which originally laid the foundation of this noble institution. I have thus far endeavored to reply to the inquiry made under your first head, relative to "the origin and progress of this undertaking."

In reply to your second inquiry, relative to the moneys expended for land, instruments, and books, distinguishing between the amount appropriated by the University from its own resources, and that derived from the contribution of others, I respectfully state that Mr. Eliot, the Treasurer of the College, is now preparing a full and exact statement of the moneys expended, and the liabilities incurred up to this time by the Corporation, on account of the Observatory, for his next annual report to the Board of Overseers; but the state of his documents are not now so far prepared and arranged as to admit of their now being transmitted to you, with sufficient specific details. It will be, however, probably sufficient for your present purposes, and sufficiently evidence the spirit with which the Corporation has met and co-operated with that of the subscribers to this great undertaking, for me here to state, that they have already actually expended for land, buildings, books, and incidental claims arising out of the Observatory, in round numbers, the sum of $ 35,600, and that the Corporation is under contract for $ 17,300 on the same account, constituting an aggregate of $ 52,900 already expended, either in fact, or by being under effective contracts; of which they have received $ 25,000 from subscribers, leaving the sum of $ 27,900 to be supplied out of the funds of the University. These facts will appear with more precision in a document from the Treasurer, and subjoined to this Report, marked F.

In reply to your third inquiry, "a plan of the land purchased, on which the buildings are erected," has been already referred to, and is subjoined, marked E. For a plan of the buildings themselves, of their internal arrangements, of the fixtures of the instruments, and a description of the great Fraunhofer telescope, ordered from Munich, and the other particulars contained under this head of inquiries, I ask leave to refer to two documents marked G and H; the former containing a specification of the relations of the respective buildings and tower erected for the Observatory; the latter, entitled "Data, &c.," and intended by Mr. Bond as an answer "to some of the inquiries in your letter."

On your fourth inquiry, relative to the mode of appointing the Observer and his Assistant, the tenure of their several offices, their right of occupation of the Observatory and the adjoining grounds, I would observe that these appointments naturally fall, under the constitution of the College, within the general powers of the Corporation, subject to the controlling sanction or rejection of the Board of Overseers. All the other points suggested under this head of your inquiry are subjects of grave deliberation, to be prospectively settled, and will naturally become objects of early attention by the Corporation, and being adopted after consideration by that body, or in conjunction with the Committee of the Overseers on the Observatory, will be finally submitted, as in the case of Statutes of Professorships, for ultimate sanction, to the Board of Overseers.

In respect of the other topics touched upon in your letter under this head, relative to the division of duties between the Observer and the Perkins Professor of Astronomy, their respective rights of using the instruments, how far access may be allowed to the latter to the Observatory, and to the instruments for the purpose of instruction; the indulgence which may be extended to students, of assisting at the observations, or making use of the instruments; also in respect of the several topics alluded to in your 7th, 8th, and 9th inquiries, concerning the journal record of observations, the reports to be required, and the duties to be enjoined upon the Observer, the books and European publications upon the subject of Astronomy now possessed by the Corporation, or which it may be deemed necessary to procure for the Observatory, the periodicals to be readily and speedily obtained, and the cost of procuring them, with the other questions raised by these inquiries, they are, I apprehend, all of them, or at least chiefly, replied to in the following documents, to which I respectfully refer, and which I request you would regard as my answer to these several points to which in your letter you have requested my attention, viz.: —

1st. The letter of Mr. Bond, already referred to, entitled "Data, &c.," and marked H, dated May 19th, 1845.

2d. The letter from the same gentleman to me, dated June 11th, 1845, marked I.

3d. A document entitled "Duties of the Director of the Cambridge Observatory," without signature or date, but in the handwriting of Mr. Bond, marked K.

4th. A document, also without date or signature, but in the handwriting of Professor Peirce, relative to the duties of the Director of the Observatory, and of the Perkins Professor, marked L.*

5th. A letter from Professor Peirce to me, dated June 7th, 1845, marked M, in which he refers to a letter previously written to me, dated May 7th, 1845, which is subjoined, marked N. I also subjoin another letter from him to me, marked O, and dated May 10th, 1845, in which he places the important services of Mr. Bond in a strong and most impressive light, and enforces the duty of taking immediate and efficient measures to raise funds to make his future connection with the Observatory certain and permanent. In this tribute to Mr. Bond, and in this opinion of the urgency of the duty of not permitting any delay to occur in permanently securing Mr. Bond's services for the Observatory, and thus enabling him to lay aside all occupations except those connected with the office of Observer, my own judgment and opinion concerning the interests of the Observatory fully concur.

With this last letter Professor Peirce transmitted to me two letters, addressed to Mr. Bond from Mr. Beaufort, the Hydrographer to the British Admiralty, dated the 29th of January, and 4th of April last, from both which it appears that the talent of Mr. Bond begins to be justly appreciated by European astronomers, and that they begin to take a great interest in our Observatory, and place great confidence in the observations of Mr. Bond.

The topic at this moment the most interesting to the Observatory, and which, to insure its success, most imperiously claims early attempt and exertion, is that touched upon in your 5th and 6th inquiries, relative to the compensation of the Observer and Assistant Observer, the mode of obtaining the required funds, the amount which ought to be raised, how far resort should be had to the liberality of individuals, and what can be expected to be derived from the resources of the University.

It is impossible for me to answer this question fully, without again alluding to the services of the present Observer, which I regard as inestimable. I have already sufficiently alluded to his qualifications. They are well understood and appreciated in this vicinity. It appears by the letter of Professor Peirce to me, dated May 7th, that attempts have been made to withdraw his services from our Observatory; and I have reason to fear they will be renewed. Now it is not too much to say, that the success of this noble attempt to establish this Observatory essentially depends upon retaining those services for it.

I am well aware, and have frequently heard others speak, of the attachment of Mr.

---

* Documents G, H, I, K, and L are omitted.

Bond to this vicinity, and that his affections are so intimately entwined with our Observatory that it is not probable that any salary which would be offered could tempt him to quit his present position. Yet I think it is not wise to calculate with too great assurance on the effect of these affections and predilections, and thus delay making a due and permanent provision for his support. Besides, in my judgment, the present circumstances of the relation of Mr. Bond to the University are neither just to him, nor yet very reputable to the friends of the University, and to those interested in the science of astronomy in this vicinity. Mr. Bond has for five years been devoting all the time he can spare from his business to the interests of astronomical science, and to the magnetic and meteorological observations already noticed, absolutely without any salary or compensation from the University, except the rent of the house occupied by himself and his family. It cannot possibly be expected, and ought not to be asked, of a gentleman so qualified, so zealous and assiduous in a cause of such great general and public interest, to forego the advantages of full compensation for his services proffered to him elsewhere, out of regard to his personal preferences for this part of the country, and predilections for this interesting and recent establishment.

The great telescope is expected from Europe early in the spring of 1846. As soon as it arrives, Mr. Bond will necessarily be required to devote his whole time to the Observatory, and ought to be enabled to give up his business and thus devote himself. This cannot be even asked, unless a sufficient and permanent salary be provided for him. And this can only be obtained by applying to the same liberal and patriotic spirit which has so nobly laid the foundations of this institution. Without a scientific Observer, all that has been already contributed will be lost to science, and useless. To secure such an Observer, an adequate salary is absolutely necessary, now, and in all future times. The exertion to be made, therefore, to obtain the funds necessary, should not be made on a temporary scale, or in any respects personal, but for the supply of a want which must at all times exist. What is required, and ought to be endeavored to be attained, is a permanent fund to be for ever exclusively applied to this essential object.

As to the amount which ought to be raised for this purpose, I apprehend there can be but one opinion among reflecting and intelligent men upon the subject.

An Astronomical Observer, qualified for the office, cannot be expected to be obtained for less than a Professor's salary, or for less than $ 1,500 to $ 1,800 per year; not only the great and peculiarly intellectual power and physical endurance which such an office requires, but the draft upon the Observer's health which long and successive nocturnal watchings exacts, render it just that the compensation should be full and satisfactory.

In addition to the principal Observer, an Assistant Observer should be provided; it being impossible for any single individual to execute the successive duties which nightly watching of the heavens include. Such an assistant well adapted to the task cannot be hoped to be obtained for less than *one third* of the salary of the principal Observer. So that for a permanent provision for both these essential objects, a capital annually producing twenty-five hundred dollars ought to be raised; in other words, a capital fund of at least *fifty thousand dollars.*

Notwithstanding the apparent greatness of this required amount, yet, taking into consideration the essential nature and all-importance of the object to the success of the Observatory, the universal confidence in the qualifications of Mr. Bond, and also the very general desire among those who are interested in the institution to fix him permanently in the office he now holds, I cannot doubt that, if the committee of the Overseers will lend their name and influence to the attempt to raise the specified sum, it will be successful.

Already a single individual (the Hon. Mr. Sears) has recently made a donation, as a foundation and beginning of a fund destined for this very object, of *one tenth of that sum;* and I cannot question that a like spirit, on application to it, will be found ready and willing to meet the exigencies, and permanently provide for the want, among other liberally disposed citizens of Boston and its vicinity. In answer to your inquiry, what amount it would be in the power of Harvard College to contribute to such a fund, my own opinion is, that there are many strong and conclusive considerations which render it expedient that this fund should be established independent of any resort to the Corporation of the College.

In the first place, I think it for the honor, and due to the character, of the citizens of Boston and its vicinity, whose liberality has already founded the tower and provided the means for a telescope unequalled in point of power in this country, and not inferior to any in Europe, that the only great remaining permanent aid requisite for the success of the institution, and indeed essential to the usefulness of their former bounty, should proceed from the same generous spirit to which the public is already so largely indebted. It ought to be understood that the citizens of Boston did not intend to do anything by halves; that one and the same generous spirit which provided the tower and the instrument also established the means adequate to obtain and for ever sustain the astronomical intellectual power destined to render it useful, not only in the present, but in all future times.

I do not think that, for the establishment of a fund for the salaries of the Observers, the Corporation of the College ought to be called upon to contribute at all;—not only from the consideration above intimated, but for other reasons. That body has already sufficiently evidenced its disposition to meet and keep pace with the liberality of the public, as the statements made in this letter have abundantly shown. Besides these salaries, there must be constantly required advances for objects necessary for the use of the Observatory, which it must unavoidably fall upon the College funds to supply; and it is therefore important for the Observatory itself, that their funds should be kept unexhausted and unencumbered. The College already contributes permanently for the use of the Observatory the Perkins Professor of Astronomy. The interest naturally created, in such a body as is the Corporation of the College, in such an institution, is a sufficient guaranty of an ever-existing disposition in it to fulfil the wishes and co-operate with the liberality of the community, by an expenditure to the utmost their resources warrant, and of which what they have already done is an evidence for the past and a pledge as it respects the future.

I have thus, Sir, very inadequately, but I hope not wholly ineffectually, endeavored to reply to the many searching and interesting questions you have raised in the course of your suggested inquiries relative to the present state and future prospects of the Observatory at Cambridge, established by the citizens of Boston in connection with and under the superintendence of Harvard University.

For the degree of success which the institution has already attained, it is largely indebted to you for that active and intelligent zeal, as well as liberal spirit, which more than twenty years ago you displayed in favor of this great undertaking. Although at that time the attempt was unsuccessful, your spirit has never failed to hover over the design, and to foster and encourage every indication of a disposition arising in the community to carry it into effect. And I cannot but hope, that, after so much has been done in accordance with your long-continued wishes, the same intellectual zeal and scientific spirit which so long interested themselves in the establishment of this institution will again be exerted, and be effectual in raising a fund for the supply of its most permanent and urgent wants, and that you may at last, in your advanced age, have the happiness of seeing an institution which has been so long among the most cherished wishes of your heart permanently established, and supplied with its only remaining great want, upon a scale in some degree at least approximating your scientific desires and patriotic hopes.

I am, Sir, with the highest respect, your obedient servant,

JOSIAH QUINCY.

# A.

## *Extract from the Appendix to Quincy's History of Harvard University,* Vol. II. pp. 566–568.

### THE ASTRONOMICAL OBSERVATORY.

THE establishment of an Astronomical Observatory at Harvard College, having long been an object of anxious solicitude to its friends, a brief account of its history, and the degree of success with which it has now commenced, may be satisfactory and useful. In 1816, John Farrar, then Hollis Professor of Mathematics and Natural Philosophy, and the late Nathaniel Bowditch, were appointed by the Corporation a committee, with full authority to order instruments suitable for an Observatory, to be built for the College. Owing to difficulties arising from the European artist whom they desired to employ, this power was never executed, and nothing of importance was done except procuring plans and sketches relative to a building.

The design was revived in 1822, and the same committee examined various positions in the vicinity of the College, for the purpose of selecting the most suitable for an Observatory. A report was made very favorable to a position in that vicinity, on land owned by Edward Dana, and an authority was given to purchase two acres and a half for that purpose. The negotiation failed, and further proceedings were postponed.

In October, 1823, John Quincy Adams, then Secretary of State to the United States, addressed a letter to a member of the Corporation, urging that a building should be erected without waiting for instruments from Europe, and recommending that the site nearest the College should be selected, even should it occasion some addition to the expense; proximity to the College being, in his judgment, important to the health and comfort of both the professor and the students, as the night and the winter are the time and season specially adapted to astronomical observations. Mr. Adams strongly recommended a subscription to be opened for the purpose, and, upon condition that the requisite sum should be raised in two years, authorized a thousand dollars to be put down on his account, but requesting his name to be concealed. The attempt, however, did not succeed. In October, 1825, the limited time in his former subscription having expired, he wrote again to the same member of the Corporation on the subject, urged a renewal of the attempt, and renewed his offer of one thousand dollars, on the same conditional limitation of two years. About this time an address to the public was prepared and published, and a subscription opened, but in the result proved insufficient.

No public endeavor was made for this object until the autumn of 1839. During the interval, the land formerly selected as a site for the Observatory had been purchased, and thus one great requisite for success was attained. The house on this land was also large and commodious; the site for the Observatory, the best in the immediate vicinity of the College, and satisfactory. When the subject was communicated to the friends of the design, their opinion was unanimous that the opportunity was highly favorable for its commencement. Funds adequate to the buildings immediately requisite having been readily obtained, the house was furnished with all the additions that were needed to fit it for its intended purpose. The Observatory has now at its command, from the College apparatus and the instruments belonging to Mr. Bond, a transit-instrument, and variation transit, by Troughton and Simms; an astronomical clock; one refracting and two reflecting telescopes; an astronomical quadrant by Bird; a Gauss magnetometer; a small transit by Bird; a quadrant and sextant; with chronometers, thermometers, barometers, hygrometers, dipping and variation needles. To render the Observatory as efficient as could be desired, there is wanted a refracting telescope, equatorially mounted, a mural circle, and a large transit-instrument. These, it cannot be questioned, will soon be supplied in some form, by the liberality of the public, or individuals, as soon as the advance already made towards a sufficient apparatus for an Observatory shall be understood and realized.

Although the apparatus possessed by Mr. Bond was excellent, and sufficient for the observations in which he was engaged in connection with the Exploring Expedition, yet it was not expressly adapted to the purposes indicated by the Royal Society of Great Britain, in their address to the several scientific societies in Europe and America on the subject of a conjoined and contemporaneous series of observations on meteorology and the elements of terrestrial magnetism; and the American Academy of Arts and Sciences, in Boston, being desirous to co-operate with the Royal Society of Great Britain on this subject, and to aid also the exertions in this direction of the Corporation of Harvard College, appropriated one thousand dollars for the purchase of the requisite instruments, in conformity with the suggestions and request of the Royal Society, deposited them in the rooms of the University, and placed the whole at the disposal of Professor Lovering and Mr. Bond, and have thus enabled the College early to become one of the few magnetic stations yet established on this side of the Atlantic.

A regular series of observations is now, and for these eight months has been, making by Mr. Bond and Professor Lovering, with the valuable assistance of Benjamin Peirce, the University Professor of Mathematics, a publication of some of which it is expected will soon commence, and be afterwards regularly communicated to the public.

## B.

### *Letter from Professor Lovering addressed to President Quincy.*

Cambridge, June 9, 1845.

My dear Sir: — I will endeavor briefly to answer your inquiry as to the state of the apparatus, useful in astronomical observation, at the time Mr. Bond became connected with the College. I think that at that time the College did not possess a single instrument which was adapted to making an astronomical observation which would have any scientific value.

1. There was at that time under my charge an Astronomical Clock.* I do not recollect the maker's name, but Mr. Bond, who now has it, can probably tell. This clock could not be relied on for accurate time, on account of the imperfect compensation of the pendulum. The substitution of the mercurial for the lever compensation would make this a valuable auxiliary to an Observatory, if the clock is as good in other respects as I think it is.

2. The College possessed a small Transit-Instrument; this transit-instrument was lent, for a time, to Dr. Bowditch; it was returned since I had charge of the apparatus. I think that Dr. Bowditch found it of little value. This instrument falls so far below the average of such instruments, as they are now made, that it has outlived its usefulness. I think that Mr. Farrar had a granite slab in his garden to stand the instrument upon, but no further provision existed for giving it stability. This instrument is now at the Observatory, in the charge of Mr. Bond, who will give you his opinion of it. I think the maker was Bird, but I am not sure of this.

3. A Gregorian Reflecting Telescope, three feet focal length.

4. A Refracting Telescope, three feet focal length, by E. Nairn.

5. A Gregorian Reflecting Telescope, two feet focal length, made by Short.

These three instruments answered decently well, for showing the moon, Jupiter's satellites, Saturn's ring, &c., &c. to the students; but they were very imperfect for any nice observation. The achromatism of No. 4 was very imperfect, though this on the whole was the most useful of the three.

No. 5 was the largest, but the mirrors needed to be repolished, and the mounting was not sufficiently firm, without resting the instrument on a solid pier, to be relied on. This instrument was placed in the small tower at the old Observatory, but was of no use there for want of stability. I think that Mr. Bond has said that this instrument, after its mirror had been repolished and it was placed on the pier at the new Observatory, worked very well.

---

* This clock is probably the same as that with which Professor Winthrop observed at Newfoundland the Transit of Venus in 1761.

But all these instruments, however good in other respects, would have no great value at the present day for a large class of astronomical observations, for want of an equatorial mounting, and a clock movement to compensate for the earth's motion. They might answer to observe an eclipse or a transit with, provided the observer was furnished with accurate time.

6. An Astronomical Quadrant, or altitude and azimuth instrument, by Sisson.

7. A common Quadrant, by Martin, presented in 1764 by E. Goldthwait, and two Sextants, one by Dolland.

This completes, I believe, the catalogue of articles which can be considered as having any connection with astronomical observations. It would seem that, at the time when Mr. Bond first became connected with the College, the University possessed no instrument of much value for determining either time or position, the two great elements which the theoretical astronomer wants, and which the Observatory is expected to furnish; neither was there at that time any place more convenient for using such instruments as the College then enjoyed, than an open field, or a window which might accidentally open in the right direction, with only that small amount of stability which might accidentally be found, at the particular time and place.

Respectfully yours, &c.

JOSEPH LOVERING.

HON. JOSIAH QUINCY.

---

## C.

*Vote of the Corporation of Harvard College relative to an Agreement with Mr. Bond.*

AT a stated meeting in Boston, November 30, 1839,

The Committee appointed in October last report that they have made the following agreement with Mr. Bond, which is submitted for the consideration of this Board.

By order of the Committee,

(Signed,) JOSIAH QUINCY.

*November* 29, 1839.

Mr. Bond agrees to remove his astronomical, magnetic, and meteorological apparatus to Cambridge, and place the same under the control of the Corporation; reserving, however, to the said Bond, the exclusive use of said apparatus for any observations necessary for his fulfilment of any contract he has made with the government of the United States, or for the accurate observations of *time* for the use of his private business, as regulator of chronometers.

All observations made by him may be published at his discretion; but if published, they shall be as made by him, as Astronomical Observer for the College; but no use or publication of them shall be made, which shall in any way militate with the engagements said Bond has entered into with the United States, as aforesaid, nor shall they be published without said Bond's authority.

The said Bond shall make at all times whatever observations the said Corporation may require, and in case of his neglect, or refusal, it shall be the right, and in the power, of the said Corporation, to direct and cause them to be made by the Professor of Natural Philosophy for the time being at the College; by whom the said apparatus may be used for such purpose; provided that such use shall not interfere with the rights hereinbefore reserved to said Bond.

And the Corporation agree, that they will be at the expense and risk of removing said apparatus to Cambridge, and of erecting a satisfactory Observatory, and that they will appropriate the Dana House (as it is called), for the use of his family, reserving the southwest lower room as an Observer's room, to be used in common by the said Bond and the Professor of Natural Philosophy for the time being at Cambridge, and the chamber over the same, together with the small room adjoining, for the exclusive use of said Professor. It being understood, that, as Mr. Bond receives no salary from the College, he shall be at liberty to pursue, as at present, his private business, and shall enjoy exclusively all the advantages of any contract he has made with the government of the United States relative to his observations. And also that all books and stationery necessary for making or recording any observations the Corporation may direct, other than those for Mr. Bond's private use, and for his fulfilment of his contract with the government, shall be provided at the expense of the Corporation.

This agreement to continue for five years, at the end of which time the said Bond shall have the right to remove all his said apparatus from the College if he see fit.

*Voted*, That the Report be accepted.

## D.

### *Vote of the Corporation relative to a Proposition from the American Academy of Arts and Sciences.*

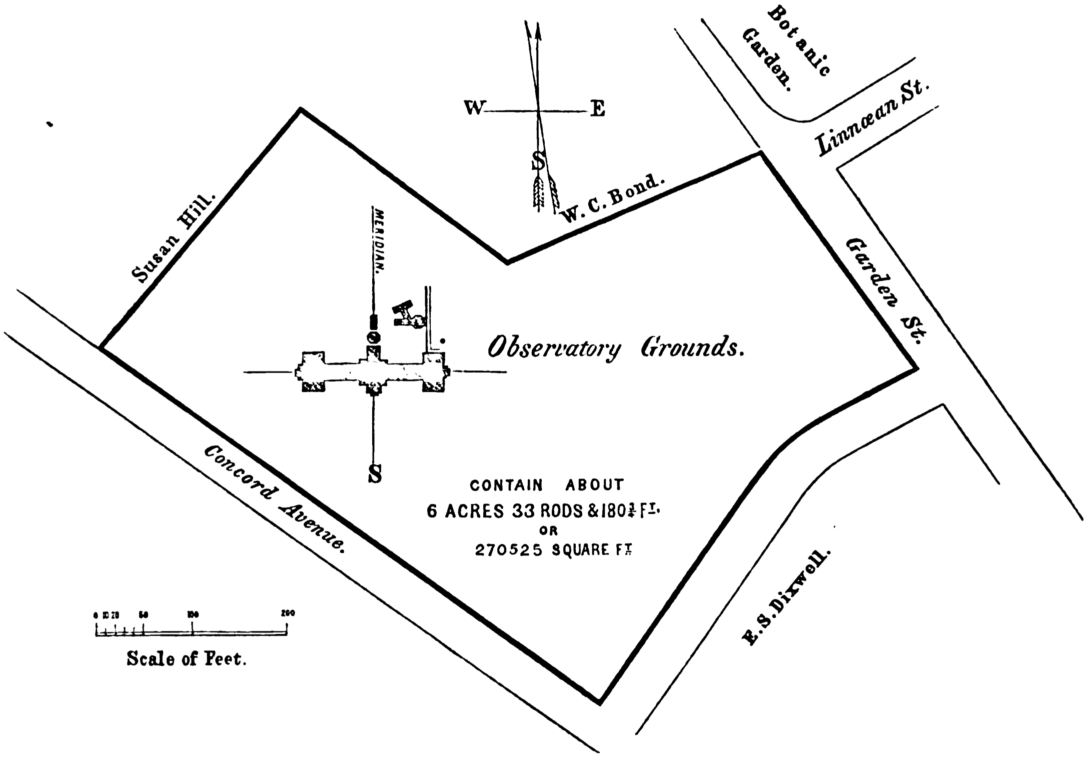
At a special meeting in Boston, February 12, 1840,

The President stated to the Board a proposition made to him by a committee of the American Academy relative to an appropriation of a sum to be applied to the purchase of instruments for magnetic and meteorological observations; which being considered, thereupon

*Voted*, That, if the American Academy of Arts and Sciences shall appropriate a sum not less than eight hundred dollars for the purchase of instruments suitable for making magnetic and meteorological observations, and shall cause the same to be placed in the building lately erected for that purpose by this Corporation, for the use of the Professor of Natural Philosophy and Astronomical Observer of the said College for the time being, it is hereby declared and agreed, that the record of the original observations, made with those instruments, shall be the joint property of the said American Academy and of Harvard College, and that all such observations shall be made according to the plan prescribed by the Royal Society of London, in their letter addressed to the said American Academy, with such amendments as the said Royal Society may hereafter propose, under the joint superintendence of the President of the American Academy and the President of Harvard College for the time being, and that the publication or other use made of said observations shall be under the joint authority of both the Academy and the College; it being understood that the instruments thus purchased shall always be and remain the property of said American Academy, and at all times subject to their order of removal, and also that the Corporation of Harvard College may put an end to this connection whenever they see fit.

## E.

*Plan of the Grounds of Harvard College Observatory.*



---

## F.

*Answer of the Treasurer of Harvard College to the Inquiries made by Mr. Adams.*

1st. The number of acres of land in the original purchase for the Observatory, obtained from the Foster heirs?

*Ans.* 11 acres 20 poles, making 484,605 square feet.

2d. The number of acres adjoining, purchased of Miss Hill?

*Ans.* 1 acre 68 poles 198 feet, making 62,271 feet.

3d. The quantity of land fenced off and set apart for the Observatory, including all the elevated part of the ground, and also that purchased of Miss Hill?

*Ans.* 270,525 square feet.

4th. The cost of the whole land above purchased?

*Ans.* $ 8,288.85.

5th. The cost of the land set apart for the exclusive use of the Observatory, at the rate of the original cost of the whole?

*Ans.* $ 4,100.00.

6th. What moneys have been expended, exclusive of the sum subscribed?

*Ans.* Expended to the present time, $ 35,604.67; under contract to be expended, about $ 17,375.04; making $ 52,979.71. Sum subscribed, $ 25,000.00; leaving $ 27,979.71 to be paid by the University.

---

## *Extract from the Report of the Treasurer of the University.*

### 1845-46.

It is due to the patrons and promoters of this great object, that they should be particularly informed of what has been done in furtherance of the design, of the way in which the funds have been used, and what additions have been made to them from the resources of the College.

In the first place, the land on which the edifices stand belongs to the College, and was purchased for the purpose of erecting an Observatory upon it a short time before the subscription was raised, at a cost of $ 8,500. A considerable part of this may be sold again, as it will not be wanted for the purposes of the Observatory, and a small portion has already been disposed of; and it is hoped that the rising value of real estate in Cambridge may reimburse to the College a not inconsiderable part of the cost. That the purchase was a judicious one, so far as regards the object for which it was obtained, is shown by the opinion in its favor expressed by all those most interested in the success of the institution, and by all the scientific persons who have visited it. The buildings are situated on a knoll of seventy-five feet elevation above the level of high tide, which, after a gentle descent of a few rods towards the south, falls off so abruptly to the level of the marsh that it does not admit the erection of any buildings of such size as to interfere at all with observations in that direction; while on all other sides the College owns the highest part of the hill to such a distance as to render extremely improbable any interference whatever.

The height of the pier on which the principal instrument is to stand is twenty-one feet above the ground, and the stone to which the telescope is to be attached is about eleven feet in height, so that it will stand thirty-two feet at least above the top of the hill. The foundation extends nearly as far below the surface as the pier does above it, and the size of the structure varies from twenty feet in diameter at the bottom to ten feet at the top. As it was necessary that a portion of the pier should be hollow, to accommodate the machinery by which the telescope is to be moved, it was thought expedient to diminish the amount of materials used in the structure, without at all diminishing its firmness, and to make the cavity in the interior of the shape of an inverted cone; so that the top stone rests on a rim of mason-work two feet wide only, leaving a space of six feet in diameter on the inside of the pier vacant. The soil excavated for the foundation appeared of quite a uniform consistency, and dry, with here and there a small vein of sand. In removing one of these little veins it was discovered that the excavation had been made precisely on the spot where what is well remembered by many of the inhabitants of Cambridge as the summer-house of the late Dr. Craigie once stood. The lower part of that structure had been used as an ice-house, and the deep excavation had been loosely filled up with stones, earth, and rubbish at the time when the building was destroyed. The loose materials were removed, and a space opened twenty feet in depth and twenty-two feet in diameter; eight feet in depth of this was filled with concrete, a mixture of hydraulic cement and gravel, which at such a depth will be exposed to an almost uniform temperature and degree of moisture, so as to constitute a foundation as nearly immovable as anything of which foundations can be constructed. At the depth of twelve feet below the surface the stone-work commences, and is laid solid, of large blocks of granite, hammered on the upper and lower sides, and well bedded in hydraulic cement to about the level of the natural surface of the ground. The hollow construction then begins, and is carried up twenty-one feet, as above stated. The solidity and immobility of this structure would seem unquestionable, and it is surrounded by a wall of brick laid in cement, and is to be surmounted by a dome, to protect it and the instrument it is to sustain, as far as possible, from all the disturbing influences of the atmosphere.

The construction of the dome is a work of no small difficulty, as it is requisite that it should revolve, and should be provided with an opening five feet wide, extending from the bottom to a little beyond the centre, which may be opened at pleasure, and closed with entire security against the violence of the storms to which its elevation and solitary situation necessarily exposes it. The tightness of this opening is to be secured by covering it with slides of copper upon an iron frame, which are moved by rack-work attached to the side of the opening, and which, shutting over each other at the top, and lapping over a raised strip on the outside of the dome upon each side of the opening, are believed to be a sufficient security against any but very extraordinary exposure. The frame of the dome is made of planks, which are covered and lined with boards, and the air in the spaces between the ribs will circulate freely by means of orifices left at the top and bottom, so as to prevent the heat of the summer accumulating in the interior, and producing an undulatory motion of the air by its escape at the moment when observations are to be made. The outside covering of the dome is of copper, which was considered the most enduring material, and that which would afford the greatest security against fire in case any of the adjoining buildings should be burnt. As a further security against combustion, double iron doors are placed at all the entrances to the central building from the adjoining apartments, and iron shutters on all the windows by which fire can be communicated from without, so that there is no way for flame to enter; and if it were possible, there is nothing combustible within but the two floors, and these have an inch of mortar between the boards, so that even they can hardly be considered as combustible.

Besides the large pier above described, there are three smaller ones, of a different shape and construction, for the purpose of sustaining smaller instruments, which require to be supported with great steadiness and adjusted with nicety. One of these is on the north side, and two on the east side of the principal building, in the gallery connecting it with the dwelling-house of the Observer. They are constructed with concrete cement and coarse sand or gravel mixed together, and are pyramidal in their shape, being eight feet by six at the bottom, and six feet by four at the top. A few inches only were laid at a time, and when those were consolidated, a few inches more were added, till the whole reached the requisite height. On each of them is a well-dressed block of granite, six feet by four, and nearly two feet thick. On this stand pyramidal stones, about five feet in height, which support the instruments. As the ground falls away considerably on the north and east sides of the large pier, the concrete foundations of the three smaller ones were surrounded by earth to the depth of several feet, piled about them to aid in securing that uniformity of temperature which is important to the immobility of the fabric.

The apparatus under the charge of Mr. Bond for meteorological and magnetic observations has been removed from the old Observatory to the new, and the dwelling-house has been occupied by Mr. Bond since October last. It is a convenient and comfortable house, constructed with due regard to economy and security. It is furnished with a well, a large cistern, and a reservoir, — the latter at a short distance down the northerly declivity of the hill; and all of them would be available to extinguish any accidental fire among such a number of wooden buildings. In order to afford the occupant of the house the great convenience of a pump under cover, an Artesian well was attempted, and though water was obtained, yet, as it was encumbered with quicksand that could not be got rid of, it was abandoned, and a common well was dug. This loss, the only material one in the whole operation, will be partially remedied by the utility of the cavity of sixty feet depth in experiments on temperature. The road by which access has been given to the house and Observatory is carried at such a distance from them as to give no ground of apprehension of disturbance from the passage of any vehicle over it. The nature of the soil, too, favors the security from jarring from any such cause.

It will be no surprise to those who are acquainted with the nicety and firmness of the style of work required, and who recognize the difficulty of doing things upon novel plans, that all this should have cost a large sum of money. It was, of course, extremely important to the College that none of its funds should be wasted in the prosecution even of this excellent work; while, on the other hand, it was no less important that everything should be done that was deemed necessary by the officers who were to have the principal charge of the Observatory, and not only done, but done in a manner which should be satisfactory to them. It was important also that the public expectations should not be disappointed by any misplaced spirit of economy; as it might be confidently supposed that the liberality which began the work would carry it on to the point of efficiency, provided there were neither waste nor idleness. Every effort has, therefore, been made to do what was necessary, and no more than was necessary. Still, with all the care that could be used, the Observatory account stands charged with a balance of more than $ 9,000 against it. Of this, about $ 6,500 have been paid for instruments, and the remainder has been spent on the buildings and the grounds. A further sum remains to be paid on account of the dome, which is not yet completed; and $ 13,500 are to be expended on the large telescope, and a transit-circle which has been ordered from London. So that, on the whole, the College will have spent on the Observatory nearly double the sum that it has received. It is believed that whoever examines the work will be satisfied that the same amount could not now be performed for less money, and that nothing has been done which was not indispensable to the utility of the structure.

It would have been the reverse of wisdom to have wasted the whole establishment by the imperfection of any part, and it would have indicated no very flattering appreciation of the merits of the officers who are to be intrusted with the use of the instruments, if anything had been neglected which they deemed essential, or if all reasonable pains had not been taken to satisfy their scientific accuracy.

The estimation in which the services of Mr. Bond are held elsewhere has been shown, during the past spring, by the almost unlimited offers made to him by the administration at Washington to induce him to take charge of the Observatory there. And when it is known that his labors here have been entirely unrequited, except by the gratification of his love of science and of home, it is hoped that the sacrifices he has made will be properly estimated, and that some adequate provision will be made to enable the Observatory to command his time, and the labors of others under his direction.

S. A. Eliot,
*Treasurer of Harvard College.*

## O.

### *Letter of Professor Peirce to President Quincy, with two Letters from Admiral Beaufort annexed to it, and a list of Zenith Stars from Professor Airy.*

Cambridge, May 10, 1845.

My dear Sir, — It may be useful at this time to be able to state, that the two principal elements which are essential in the establishment of an Observatory, its latitude and longitude, have been determined by Mr. Bond with *astronomical* accuracy, that is, well enough for the purposes of a great Astronomical Observatory. This has been done for no other position in the country.

The longitude requires a long time for its perfect determination; but the following statement will show that we have sufficient authority to corroborate the assertion with regard to the accuracy of Mr. Bond's longitude of the Cambridge Observatory, or (what is identical with this) that of Boston. A few years ago, Commodore Owen, of the British Royal Navy, was sent to this country to survey the coast of New Brunswick and Nova Scotia, and is still engaged in this work. As it was of the first importance for him to have a well-determined point to which he might refer all his differences of longitude, so as to refer them to Greenwich, he examined with scrupulous care the different determinations in the country, and decided that Boston was altogether better determined than any other place. He therefore fixed upon Boston as his point of departure, notwithstanding his own government had taken especial pains to ascertain the longitude of Halifax, which was also a much more convenient place, from its immediate proximity to his sphere of operations. He had his chronometers sent from England to Mr. Bond, actually passing through Halifax, and came repeatedly himself to Boston, for the purpose of connecting his own stations (Halifax included) with this city. He sent his results upon this basis to the Lords of the Admiralty, where they met with considerable opposition from gentlemen who had taken a personal interest in determining the longitude of Halifax, and regarded the Commodore's adoption of Boston with natural feelings of jealousy. Mr. Bond was, therefore, called upon to furnish his authorities for the longitude of Boston. I may here remark, that although Mr. Bond's longitude of Boston is identical with that given by Dr. Bowditch, from a transit of Venus, and two or three solar eclipses, his authorities, in addition to those quoted from Dr. Bowditch's Memoir in the American Academy, consist entirely of his own observations.

Mr. Bond has observed a great number of occultations and moon culminations, and twelve chronometers, which were brought directly, in the steamer, from the Greenwich

Observatory to Boston, one moiety being for Commodore Owen and the other for our own government. With the present means of communicating with England, this last method can be used nowhere else but at Boston; and the method of moon culminations, which is considered by astronomers to be the best of all methods, has never been attempted by any one but Mr. Bond upon this continent, and requires at least a year for the first approximation. Mr. Bond sent a detailed account of the results of his observations, to which he received a most satisfactory reply from Captain Beaufort, on the part of the Board of Admiralty; it is the annexed letter, dated January 29th, 1845, and is conclusively and unequivocally in favor of Mr. Bond.

In the survey of the Northeastern Boundary, some difference of opinion has arisen between our own and the British Commissioners with regard to the longitudes; and Major J. D. Graham, our own engineer, has written to Mr. Bond for his longitude and authorities. Mr. Bond replied with the same account which he sent to England, and Major Graham has replied, that he fully concurs with Captain Beaufort in his opinion of the evidence, and does not see that there is any room for doubt.

Captain Wilkes, of the Exploring Expedition, has given his opinion substantially in the same way, by intimating that he intends to refer all his positions in the Pacific to the Cambridge Observatory.

With regard to the latitude, I will say, in one word, that ours is the only latitude in the country which is determined with the requisite precision for the higher problems of astronomy. It was ascertained by observations upon the Prime-Vertical, and may be depended upon to a second of arc. Mr. Bond requested Captain Beaufort to send him the latest determinations of the places of the stars employed by Mr. Bond in obtaining his latitude, and received the letter dated April 4th, in reply. The stars which Mr. Bond had used had been brought down by me to the beginning of 1845, from the published Greenwich, Edinburgh, and Cambridge (England) observations, and their places scarcely differ from those received from Mr. Airy. I am particularly pleased to see that, in regard to *α* Lyræ, he gives an annual variation which differs from any before published, even his own very recent one; but which agrees precisely with that which I had ventured to adopt, in the face of these great authorities, from my own examination.

Yours, very respectfully,

BENJAMIN PEIRCE.

PRESIDENT QUINCY.

London, Admiralty, January 29, 1845.

Sir, — I cannot sufficiently express my thanks for the public spirit and personal kindness with which, in your letters of October last, you went into a full statement of the authorities on which the longitude of Cambridge Observatory (Massachusetts) had been determined. We have now compared the various observations with your clear reasoning upon the subject; and I remain perfectly satisfied that the result you give is so near the truth that the limits of probable error fall far within the accuracy required for practical purposes, and that any further refinements on the observations already computed would be of little use. New series of moon-culminating stars, if made in correspondence with some of the principal Observatories of Europe, would indeed be decisive, and if you would propose any course of such observations, along with the periods, I have no doubt that the Lords of the Admiralty would recommend them to the special adoption of the Astronomer Royal at Greenwich.

Perhaps you will allow me to remark, that in the list of sixty-six moon-culminating observations, those (of 1839 and 1840) which seem to be the best, that is to say, those in which the horizontal parallax is the greatest, mostly incline to a minus correction to the assumed longitude; and secondly, that all the rejected moon-culminating observations, and most of the rejected occultations (1831, 1837, 1839) would have given a minus impulse to the result. But I have no doubt that the committee of the American Academy, to which you allude, will have duly weighed all these considerations. And I trust you will so far continue your kindness to me as to let me hear the conclusion at which they arrive.

With respect to the constant errors of the chronometers from Liverpool, which you think may participate in some error in the longitude of that place, I have the pleasure of apprising you, that the longitude of St. Paul's Church in that town is 2° 59′ 30″ W. (and latitude 53° 24′ 39″ by the Ordnance Trigonometric Survey); but I have no dependence on chronometric meridian distances, unless for very short intervals of time, and under very favorable circumstances, not only from their capricious irregularities, but from the extreme difficulty in assigning their sea-rate, that being, in nine cases out of ten, different from the land-rate, even in the very best instruments.

With real thankfulness for all your kindness, I am, my dear Sir, your obliged and obedient servant,

F. Beaufort.

W. C. Bond, Esq., *Director of Cambridge Observatory.*

London, Admiralty, April 4, 1845.

Dear Sir, — On the receipt of your obliging letter of February 28th, I applied to Mr. Airy, the Astronomer Royal, for his recent determination for you of the places of certain stars which you enumerated. His reply did not arrive in time for the last packet, but I have now great pleasure in transmitting to you (in original) his return to my request; and I trust that, on any other occasion that may offer, you will again do me the favor of making me useful.

I am, my dear Sir, yours very truly,

F. Beaufort.

### *Corrected Mean Places of Cambridge Zenith Stars, received from Professor Airy.*

| Name of Star. | Approximate Right Ascension. | North Polar Distance from Catalogue of 1439 Stars referred to Jan. 1, 1840. | No. of Obs. | Seconds of N. P. D. 1842. | No. of Obs. | Seconds of N. P. D. 1843. | No. of Obs. | Seconds of N. P. D. 1844. | No. of Obs. | Annual Variation. |
|---|---|---|---|---|---|---|---|---|---|---|
| $\gamma^1$ Androm. | h. m.<br>1 54 | 48° 25′ 89″.66 | 29 | .... | ... | 36″.84 | 2 | 18″.72 | 2 | —17″.620 |
| $\gamma^2$ Androm. | 1 54 | 48 26 25.03 | 4 | .... | ... | .... | ... | .... | ... | —17.620 |
| $\beta$ Persei | 2 58 | 49 39 57.55 | 10 | .... | ... | .... | ... | .... | ... | —14.315 |
| $\mu$ Urs. Maj. | 10 13 | 47 42 .... | ... | 30″.06 | 2 | 47.87 | 2 | 65.90 | 5 | +17.903 |
| 8 Can. Venat. | 12 26 | 47 46 19.01 | 6 | 57.56 | 2 | 78.58 | 2 | 98.02 | 9 | +19.925 |
| $\alpha$ Lyræ | 18 31 | 51 21 41.34 | 462 | 35.18 | 79 | 32.25 | 30 | 29.29 | 62 | — 3.052 |

G. B. AIRY.

1845, *March* 20.

### *Letter from the Astronomer Royal of England to Hon. John Quincy Adams.*

Royal Observatory, Greenwich, England, June 8, 1839.

Sir, — I have lately received from Mr. Christopher Hughes (whose acquaintance I had the good fortune to make on his visit to Cambridge, England, several years since) a series of questions, proposed by you, relating to the history and present constitution of the Royal Observatory of Greenwich, dated 10th April, 1839. I do myself the honor of addressing my answers upon these matters immediately to yourself; conceiving that, if these answers, or any subjects connected with them or suggested by them, shall require further explanation from me, any apparent difficulties in the way of immediate communication will thus be effectually removed.

On the supposition that you have preserved a copy of the questions, I refer to each question by its number only. Supposing that your object may be to collect information relating to existing observatories in general, I have in one or two cases mentioned the circumstances of other observatories.

I regret that there is a great deficiency of authentic documents (at least within my reach) relating to the early history of the Observatory. I regret, also, that at this moment I am not able to furnish a complete list of the prices of the instruments. I hope, however, to receive a more complete list before despatching; if it arrives too late, I will send it by a future opportunity.

With profound respect, I have the honor to be, Sir, your very obedient servant,

G. B. Airy.

John Quincy Adams, Esq., &c., &c.

---

*Answers to Mr. Adams's Questions, dated April* 10, 1839.

1. The Royal Observatory at Greenwich was built at the expense of the government in the reign of Charles II. (about 1670), and the buildings have always been repaired or extended at the expense of the government.

The instruments used by Flamsteed, the first Astronomer Royal, were not furnished by the government, and were taken away by his executors; since that time the instruments have always been furnished by the government, except in two instances, where instruments have been presented. The observations are now printed at the expense of the government. Thus every expense connected with the Observatory is defrayed by the government. The Observatory was at first connected with the Ordnance Department of the Executive (I believe from the accidental circumstance, that Sir Jonas Moore, the personal friend of Flamsteed, and one of the original proposers of the Observatory, was then Master-General of the Ordnance). In the year 1816 or 1817 it was transferred to the Admiralty Department.

The estimates for the annual expense of the Observatory are inserted under the "Scientific Branch" of the Admiralty Account in the Parliamentary estimates, and are voted annually by Parliament.

In the original institution of the Observatory, no provision was made for the printing of the observations, or for the communication of the results to the public in any way, and no obligation to that effect was imposed on the Astronomer Royal. When Flamsteed had held the office about thirty years, and had published nothing, the Royal Society applied to the Queen to appoint a Board of Visitors (one of them being Sir Isaac Newton, then President of the Royal Society) to superintend the Observatory generally, and with power to require a publication of the observations. For a full detail of the quarrel which followed, I would refer to Baily's *Account of the Life, &c. of John Flamsteed*, which may probably be found in the libraries of the scientific bodies in America. An edition of the observations was printed by them; but another edition was afterwards printed by Flamsteed himself. Halley, the next Astronomer Royal, printed nothing of observations. Bradley and Bliss left manuscripts, but the right of government to them was disputed, and they were ultimately printed by the University of Oxford. It was not till 1767, on Maskelyne's accession, that the King (George III.), on the petition of the Royal Society, ordered that the observations should be printed annually; and since that time there has been no doubt that the observations are the property of the government, and are to be printed annually.

The Board of Visitors, above alluded to, existed without alteration (as I believe) till 1830, and it was by that Board, as I imagine, that representations were made to the government which led to the purchase of instruments in Halley's time, to the regular printing of the observations in Maskelyne's time, &c. The President and Council of the Royal Society (or part of them), with a number of persons invited by them, either Fellows of the Society, or strangers, met once a year at the Royal Observatory, inspected the instruments, and discussed the general business of the Observatory. They had, I believe, no power, except to recommend measures to the executive. The meeting was rather numerous. In 1830, the old Board was abolished, and a new one appointed by name, from the Royal and Astronomical Societies.* All vacancies are filled by the President of that Society in which the vacancies occur; this Board has no power to invite Assessors; its powers as to making representations are the same as those of the old Board.

On the first appointment of the new Board there was exhibited in it a rather vexatious spirit towards the then Astronomer Royal (Mr. Pond). Since my appointment as Astronomer Royal, the Board has scarcely interfered in anything, except in matters which I have myself suggested. The Visitors receive no pay; lately it has been ordered that their bare expenses be paid.

---

* With a few official persons, as the Presidents of the two Societies, two Professors of the University of Oxford, and two Professors of the University of Cambridge, *ex officio*, — the whole number of the Visitors being about sixteen. This fluctuates, because all ex-Presidents are members of the Board.

I have given a rather comprehensive answer to No. 1, touching upon the subject of other questions, and embracing points not at all alluded to in the questions, because probably there is no other active institution whose history serves so well to suggest the points to which attention ought to be given, in founding a new institution of similar character, as well as the amount of changes which in future years may be required in all the branches of such an institution.

I omitted to mention that the Astronomer Royal's account of disbursements, and bills for expenses of all kinds connected with the Observatory, were formerly audited by the Board of Visitors; this audit was found to be insufficient, and the accounts are now transmitted, in the same way as those of any other department under the Admiralty, to the government officers.

2. For a plan of the building first erected, I refer again to Baily's Account, &c. (cited above). There were a small house, one large room above it covering nearly the whole house, with lofty windows on all sides, intended, I suppose, for gazing astronomical observations, (but quite useless for the purposes of modern astronomy,) a garden or lawn about eighty feet square, and a small low building in one corner of it, in which Flamsteed's really useful instruments were placed. The place was very small. The situation, in the middle of the Royal Park of Greenwich, has probably prevented the necessity of an enclosure so large as would elsewhere be required, inasmuch as it was impossible that houses could be built close to the enclosure.

The history in Halley's time is so defective, that I am not certain whether the building, which is to this time the principal observing building, was erected then or not, but I should think that it was; it was certainly erected before 1750, when Bradley's regular observations begin. It consists of a room about twenty feet square, for the transit, and a similar room for the quadrants, (both on the ground-floor, and with no good rooms above them,) and a central computing-room, with rooms for an Assistant above. It is not connected with the dwelling-house. When this was erected, the enclosure was nearly doubled. In Dr. Maskelyne's time, two small detached rooms were covered with revolving domes, for equatorial instruments; their situation is particularly unfavorable. In the beginning of Dr. Maskelyne's time, the dwelling-house was extended. About the end of Dr. Maskelyne's time, the observing building was extended, in preparation for a mural circle, which was not erected till after his death; some new buildings were erected for library, &c., and for assistants' apartments; a building was erected to be covered with a revolving dome (called the south dome); and an addition was made to the enclosure. The whole enclosure was now about half an acre; it covered the whole of the small steep hill on which the Observatory stands, quite to the isthmus or neck that connects it with the table-land of the higher side of the Park.

About 1817, part of the steep dell behind the hill was enclosed as a garden for the Astronomer Royal. In 1837, part of the table-land beyond the dell was enclosed for the erection of a Magnetic Observatory. The dwelling-house, which was too small, was enlarged in 1836. Thus the present state of the buildings and grounds (1839) is nearly as follows: — Whole enclosure, about two acres and a quarter, of which one acre or more can never be available for building on account of the steepness, and is used as a garden and waste ground. Whole set of buildings: — 1. Dwelling-house of the Astronomer Royal, with the great dome above part of it. 2. Two domes (east and west dome) detached. 3. Detached range of buildings, including Flamsteed's small room, the quadrant-room (not used now), the transit-room, the circle-room, the library, the chronometer-room, the south dome, the computing-room, some assistants' apartments (not for their dwelling, but for their comfort or repose in the intervals of observation). 4. Magnetic Observatory, detached. 5. Carpenter's shop, gardener's shop, and other out-houses.

The extent of ground would not be sufficient, if there were not the safety from being surrounded by building which is given by the locality within a royal park.

3. The construction of the Observatory has been altered almost entirely by additions; nearly the whole of the original work remains. The collection of buildings is now exceedingly irregular, and in some respects inconvenient.

4. The Astronomer Royal is appointed by the first Lord of the Treasury, but his connection with the Admiralty is so close, that the first Lord of the Admiralty probably has the principal influence in his appointment. He holds his office by warrant under the sign-manual of the sovereign. The salary was formerly £100. Bradley and Bliss both held it with professorships at Oxford; but the salary has gradually been raised, and is now £800 (subject to a deduction for a fund for superannuation), and it is expected that the Astronomer Royal shall hold no other office.

5. The duties of the Astronomer Royal are not very definite; but undoubtedly he is to attend to the *main* points of astronomy to the best of his judgment, rather than to anything of a *discursive* nature. The appointment originated in the desire of discovering means of finding the longitude at sea, and therefore anything applying to longitude would specially require his attention. In this way the trials of chronometers first became a part of his duty, from which, by degrees, it arose that the care and regular supply of chronometers for the Royal Navy were imposed upon him, to the great injury of the astronomical efficiency of the Observatory. Lately, the chronometer business has been confined to rating the chronometers on trial for purchase, or Navy chronometers brought on shore, with occasional supplies of chronometers to ships by direction of the Admiralty, and with general superintendence of repairs. The duties

are prescribed, first, by the Queen's warrant, which merely directs the Astronomer to apply himself with diligence to observing the heavenly bodies, for finding out the so much desired longitude at sea, (the same words as in the warrant originally given to Flamsteed). 2d. By the official instructions given by the Admiralty Board, (who have been empowered to issue instructions by the Queen in Council,) which enter a little more minutely into the duties, but necessarily leave the course of astronomical observations very indefinite.*

The Board of Admiralty sometimes call on the Astronomer Royal for a report; but it is rather upon such matters as the state of the buildings and instruments, the conduct of the Assistants, &c., than upon the nature of the astronomical observations.

I have myself introduced the rule of reading a report to the Board of Visitors at their annual meeting, at the Observatory, and this report they have each year ordered to be printed (copies accompany this paper). If this custom be continued, there will probably be found a more complete series of Annals of the Observatory than has hitherto existed.

6. Besides the Astronomer Royal there are six Assistants, and a laborer, and a watchman; also a gate porter (some old sailor from Greenwich Hospital). The duties of the Assistants are to observe and to compute, entirely under the direction of the Astronomer Royal. None of these persons reside within the precincts of the Observatory, or even within the Park; they find homes for themselves from the salaries mentioned below (part of the salary being considered as compensation for want of dwelling-house).

The salaries are: — 1st Assistant, £350; 2d Assistant, £220 (in future instances this is to be £190); 3d Assistant, £190; 4th, 5th, and 6th Assistants, £130 each; Laborer, £43; Gate Porter, £15 12*s.*; Watchman, £32 10*s.*

7. The instruments in use at this time are a Transit-Instrument, ten feet long, constructed by Troughton, bought by the government; price, I think, £300; — a Mural Circle, six feet in diameter, constructed by Troughton, bought by the government; price, I believe, £600; † — a Zenith Tube, or Zenith Sector, of small range, for the observation of $\gamma$ Draconis only (which passes very near to the zenith of Greenwich), purchased by the government; I know not the price.

---

* The Board of Visitors are empowered by their warrant under the royal sign-manual to direct the Astronomer Royal to make such observations as they may think fit; but I am not aware that they have ever exercised this power.

† Another mural circle of the same size, constructed by Jones, has lately been sent from the Royal Observatory to the Cape of Good Hope.

The Eastern Equatorial, or Shuckburgh's Equatorial, constructed by Ramsden, presented by Lord Liverpool.

The Western Equatorial, a very worthless instrument.

The Southern Equatorial, or Sheepshanks Equatorial: the object-glass made by a Parisian artist (I think by Cauchoix), presented by the Rev. A. Sheepshanks; the mounting by Mr. J. Grubb of Dublin, at the expense of the government, — its cost, £ 205.

Several Telescopes, prices unknown; some probably exceeding £ 100.

Several Clocks; the most expensive cost, I believe, £ 200.

I ought not to omit, that there is machinery for raising a large ball (five feet in diameter) on the top of the house, and dropping it precisely at one o'clock every day, as a signal by which the chronometers on board the ships in the River Thames may be rated. It was erected at the expense of the government. I know not the cost.

Besides these, there is the Magnetic Apparatus, yet imperfect; the expense hitherto incurred has been £ 30 or £ 40.

8. There is a Library, covering the walls of a room twenty feet square. It consists principally of the Transactions of Societies, and of mathematical and astronomical works, works on the literature of astronomy, Voyages, &c. In these respects it is a very good library; it has been collected partly at the expense of government, and partly from the presents of private persons and official bodies.

9. The best instrument-makers in London, at the present time, are, — William Simms (successor of Troughton, formerly his partner), 136 Fleet Street; Thomas Jones, 62 Charing Cross; George Dolland, 59 St. Paul's Churchyard.

. . . . .

The whole annual expense of the Observatory to the government, including salaries, additions and repairs to buildings, additions and repairs to instruments, and printing, exceeds £ 3,000.

### *Miscellaneous Information relating to other Observatories.*

1. The Observatory at Cambridge was built partly by private subscription, partly by grant from the funds of the University, in 1820, at an expense of about £ 20,000. It is maintained at the expense of the University. That at Oxford, I believe, was built from the funds bequeathed for that purpose by Dr. Radcliffe. Those at Edinburgh and Glasgow were commenced by private subscription, and afterwards assisted by the government. That at Armagh was built from funds bequeathed. That at Dublin in like manner.

I know not how those of Oxford, Armagh, and Dublin are maintained, but I believe that the salaries of the Observers, as well as the general support and repairs of the buildings and instruments, are defrayed from the bequests.

2. In the whole of these (Glasgow excepted, which is not much advanced) there is a dwelling-house for the Astronomer, and in some there are dwellings for assistants, connected, in all cases by building under the same roof, or by enclosed passages, with the Observatory. The enclosure of land about the Cambridge Observatory is seven acres; that at Oxford, a field perhaps not so large; that at Dublin, about thirty acres; that at the new Russian Observatory at Pulkova, about fifty acres.

3. I do not think that either of the Observatories which I have mentioned has undergone great alteration. The Cambridge Observatory, built in 1820, has not itself undergone any alteration; but on occasion of the presentation of a large telescope (twenty feet long and twelve inches aperture), a new detached building was erected for it.

I may remark, that the Cambridge Observatory was built on a plan architecturally symmetrical, which arrangement I should deprecate in any new Observatory, on account of the difficulties which it presents to all future alterations.

4. The Astronomer at Cambridge is the Plumian Professor. This officer is elected by the trustees of the estate bequeathed by a Dr. Plume, and is paid by the rent of the estate, amounting to about £300 per annum. When I was elected to the office in 1827, I represented to the Senate of the Cambridge University that this sum was not sufficient remuneration for the duties of the Observatory, and the Senate increased the payment to £500, by annual grant from the funds of the University.

The Astronomers at Oxford and Dublin are appointed by the trustees of certain estates, and are paid from their rents. I believe that the Astronomer at Armagh is elected and paid in the same manner.

For the appointment of the Astronomer at Edinburgh, the consent of the government is necessary. I know not how he is paid.

5. I do not think that in any of these instances there is any distinct set of instructions or definition of duties.

At Cambridge there is a Board of Visitors which meets at least three times each year at the Observatory, one of the meetings being attended also by other members of the University and strangers. I introduced at Cambridge the custom of reading a report to the Visitors at each regular meeting. The Visitors are required to make a report once a year to the Senate of the University.

In instituting a new Observatory, it appears to me desirable that there should be appointed a body like the Board of Visitors at Greenwich and at Cambridge, with power to require reports from the Astronomer, and perhaps to direct him in some degree; and with the duty of reporting to the governing body. The Visitors of the Cambridge Observatory are all members of the Senate of the University; the Visitors of the Greenwich Observatory are persons living in different parts of England.

6. At Cambridge Observatory there are two Assistants and a laborer. At the Cape of Good Hope, the same. At Edinburgh, Dublin, Armagh, I believe, one laborer each. Their duties, to observe and to calculate under the direction of the Astronomer. The salaries of the Cambridge Assistants are, I think, £ 80 per annum, with apartments.

7. The instruments at Cambridge Observatory are, — a mural circle, eight feet in diameter, made by Troughton; price £ 1,050. A transit-instrument, ten feet long, made by Dolland; price, I believe, £ 600. An equatorial five-foot telescope, made by Jones; price about £ 750. Several small instruments, telescopes, &c. Three clocks; one cost £ 100 to £ 120. A twenty-foot telescope, presented by the Duke of Northumberland.

At Oxford there are some quadrants not used, and also a circle, four feet in diameter, made by Jones, and an old transit.

At Edinburgh, a mural circle four feet in diameter, made by Simms, and a transit made by Repsold, of Hamburg.

At Armagh, a mural circle four feet in diameter, made by Jones, and a transit (maker not known).

At Dublin, an altitude and azimuth instrument, the vertical circle eight feet in diameter, made by Ramsden, and a transit.

I may remark, that, in the construction of instruments, expense may frequently be avoided by leaving some points to the discretion of the instrument-maker. As an instance: — When I superintended the equatorial mounting of the twenty-foot telescope at Cambridge, I found occasion for a five-foot circle, and I directed it to be cast in one piece of bell-metal; it appears to answer perfectly well. Mr. Simms is quite satisfied with it, and thinks it possible that it might be made at less expense of cast-iron. Since that time Mr. Simms has had, I believe, two orders for large circles; and when I have urged him to have each cast in one piece, he has expressed his wish to do so, but has informed me that his orders were to make them like the "Greenwich circles," and has therefore considered himself compelled to put them together in many pieces, in the same way as the Greenwich circles, at much greater expense than would have been implied in the construction mentioned above.

G. B. Airy.*

---

* The foregoing letter from Mr. Airy was found appended to the Report of Mr. Adams, although not alluded to in that document. Its interesting character and the valuable information which it contains are deemed a sufficient apology for its publication.

## *Report of the Director to the Visiting Committee of the Board of Overseers of Harvard University.*

### 1846.

Gentlemen, — Since the last annual visit of the committee, favorable accounts have been received respecting the great telescope now constructing at Munich for this Observatory. The optician, Mr. Merz, having informed the College agent, Mr. Cranch, that the two object-glasses were completed according to the terms of the contract, and that he was ready to submit them for trial and choice, it was deemed expedient to engage Mr. Simms (of the company of Troughton and Simms of London), a skilful optician, to accompany Mr. Cranch to Munich, in order to test the glasses, and make the required selection. For the details of their proceedings, and the result of their inquiries and experiments, reference is made to the letters of Messrs. Cranch and Simms, appended to this Report. These gentlemen appear to have been well satisfied with the performance of the glass selected for the College, and they saw no reason to doubt the accuracy of the judgment of Mr. Merz, when he pronounced it to be "better, very much better," than the one at Pulkova.

The focal length of the object-glass is two hundred and fifty-two Paris inches, its effective diameter more than fourteen Paris inches, and its weight in the cell forty-two Paris pounds. After the selection had been made, the crown and flint glasses were both marked on the edges: "Harvard College. W. S. J. C. May 15th, 1846."

The transit-circle which Mr. Simms is constructing for this Observatory, we have reason to expect, will be completed this autumn, but it is deemed advisable to defer the shipment of it until next spring. This instrument has a telescope of five feet focal length, and double vertical circles of four feet in diameter, which are now in process of graduation; it is to be originally divided on both faces, and will read to single seconds by means of eight microscopes. This original graduation on both faces is a serious affair, requiring much skill, time, and care to perfect, and will render our instrument more trustworthy.

The dome for the reception of the Great Equatorial is nearly completed; it moves on free balls with ease and steadiness. A model for an observing-chair, on an original plan, has been constructed and approved, and a machinist engaged to make one like it. Sliding shutters for the meridian openings have also been contrived, and a person engaged to make them. There is reason to believe that everything will be completely prepared for the reception of the two great instruments before winter sets in.

In the course of the past year a fine refracting telescope of five feet focal length, the object-glass by Merz, has been added to the apparatus of the Observatory; it has enabled us to extend our observations on comets and eclipses, while it insures greater accuracy.

The papers herewith presented to the committee will show the plan of operations which has been pursued.

Moon-culminations and transits of stars over the meridian have been observed at all hours. These observations are made in connection with similar ones taken at West Point, Philadelphia, and Nantucket, for the United States Coast Survey. It is now generally conceded that moon-culminations offer the surest as well as the most extensively available means for the determination of large differences of longitude; they have therefore received from us a considerable share of attention. It is well known to practical astronomers, that the accurate determination of the place of the moon is among the most difficult of celestial observations to make with precision, and that they are proportionally valuable. To facilitate the reduction and publication of these and similar observations, I would call the attention of the committee to the importance of providing *printed forms*, not only for the registry of observations to be preserved at the Observatory, but also for distribution; they are frequently called for, and much time is consumed in making out copies, more particularly as we now usually adopt the method of reducing each observation before sending it abroad. To facilitate this work, tables adapted to the latitude of our position and the peculiarity of our instruments have been computed by Mr. George P. Bond.

These conveniences will enable us to keep pace in the computations with the observations, and to supply the demand for copies.

In occultations of stars and planets by the moon, we have usually had the advantage of two observers. This class of observations is of much interest, and if published early might be deemed valuable elsewhere; the position of this Observatory being so well established that a corresponding observation found on our list of occultations is very nearly equivalent to a corresponding one made at a European Observatory. We have a list of more than one hundred and fifty occultations and eclipses observed at this station and in its vicinity unpublished. The details of the observations made during the progress of the eclipses of the sun which have occurred since we have occupied the new Observatory are herewith submitted, together with a large number of micrometric measurements of the distances of the cusps and differences of right ascension and declination of the sun's and moon's limbs. These are reduced according to the value of a revolution of the micrometer-screw as determined by passages of Polaris corrected for declination of the star, and the measurements are also corrected for differences of refraction, &c.

A series of interesting observations, made according to the method suggested by

Professor Bessel, has been pursued for the determination of the latitude of this Observatory. The method consists in adjusting a transit-instrument in the plane of the prime-vertical, having its axis level, and observing passages of known stars, that is, of stars whose places have been accurately determined, east and west of the meridian. When the declination of the star is accurately known, the method is susceptible of extreme nicety for *absolute* determinations, while for *differences* of latitude it is not necessary that the place of the star should have been previously determined, only that the observations made at the different stations should be on the same star about the same time. One important characteristic of this method is, that the accuracy of the results are in no wise affected by the refraction of the atmosphere. This method is therefore getting in favor for the more accurate surveys; and we have been engaged in a series of observations, made in connection with similar ones at West Point, Nantucket, and at Rouse's Point on Lake Champlain. The observations of this kind made here in December and January, 1844 – 45, have been reduced by Professor Peirce and G. P. Bond, by an expeditious process devised by Professor Peirce, and the results have been published in the Memoirs of the American Academy of Arts and Sciences. The remarkable agreement of the individual observations among themselves gives great confidence in the final result as being a close approximation to the latitude of our Observatory. When we have the transit-circle in operation, it will afford us the means of testing this result by an independent method.

The observations on comets have occupied much of our time. Four of these bodies have been discovered by George P. Bond since our occupation of the new Observatory; although he did not take precedence of all the European observers in point of time, yet in every instance he saw them before any notice of their existence had reached us.

Professor Peirce and G. P. Bond have each computed elliptic elements of the comet of February, 1846, and Professor Peirce has discussed all the observations which we have been able to procure of it. He is the first discoverer of the ellipticity of the orbit of this comet; the period is about seventy years.

Occasional observations on meteors or shooting stars have been made, and the particular phenomena attending their exhibition noticed.

The daily meteorological record has been continued at four periods of the day, and copies of the annual and monthly means furnished for publication to the Editor of the American Almanac, to Mr. Shattuck, for his Statistics of Boston, to the Water Commissioners, and occasionally to Professor Espy, and others. We have also recorded the temperature of the earth at depths of twenty feet and ninety feet.

These occupations have left us no time for keeping up a regular series of magnetic observations. The Lloyd magnetometers were put in adjustment, but have been only occasionally used. A course of magnetic observation was pursued for a short time last summer, at the request of Dr. Bache, Superintendent of the United States Coast Survey, while he was stationed at the Blue Hill in Milton. In the course of the last year observations were made in connection with Major J. D. Graham, of the United States Topographical Engineers, for the purpose of ascertaining the relative terrestrial magnetic intensity at Falmouth in England, and at Cambridge, United States.

The greater part of the magnetic observations made at the old Observatory are ready for publication. I transmitted a portion of the results to Colonel Sabine, who was charged by the British government with the care of magnetic contributions. Our curves of intensity and inclination were published in connection with those of Toronto, U. C., Prague in Europe, and Philadelphia, United States, and a copy of the work has been kindly forwarded to us by direction of the British government.

During the interval which will elapse before the reception of our magnificent equatorial telescope and transit-circle, we hope to be able, in addition to the usual duties of observation, to complete the reduction and arrangement of all our previous observations.

Respectfully submitted.

W. C. Bond.

*September* 9, 1846.

To the Hon. John Quincy Adams, Hon. Josiah Quincy, Hon. David Sears, Hon. Abbott Lawrence, J. I. Bowditch, Esq., R. T. Paine, Esq., John P. Cushing, Esq., *Committee for visiting the Observatory.*

---

### *Letter from Mr. Wm. Simms, of the Company of Troughton and Simms, to W. C. Bond.*

138 Fleet Street, London, 3d June, 1846.

Dear Sir, — It is now my duty to inform you respecting my mission to Munich, and of the selection of one of the fifteen-inch object-glasses for Harvard College, for which purpose I was sent out, and in company with Mr. Cranch arrived there on the 14th ultimo.

We gave much anxious consideration to determine what, under all the circumstances, would be the most judicious way of proceeding with our work, and resolved that our first step should be, if possible, to secure the assistance of Professor Lamont, whom we accordingly saw on the morning of our arrival. Unfortunately, however, matters that had transpired between the Professor and Mr. Merz prevented that gentleman taking an active part in the selection of the object-glass; but we received from him much friendly advice, which proved of value to us in our future proceedings.

We then proceeded to Mr. Merz's establishment, where we found all things in readiness for us; but the day was by no means the most favorable that could have been desired, the atmosphere being in a remarkably unsteady state, — so much so, that it was only by momentary glimpses that the test objects could be seen.

Mr. Merz's means for proving his object-glasses are not such as appear to me best calculated to lead to a correct result, and more especially in the case of an astronomical telescope. It is merely by the examination of a printed paper, not by directing them to the heavens, which in all cases, where it is practicable, is certainly most desirable. There was, however, no possibility of doing so in this case, and nothing remained but to make the best selection in our power with the means at our command; and in regard to the comparative merits of the two glasses, I was not long in arriving at a conclusion.

The two glasses, Mr. Merz informed us, were distinguished as Nos. 1 and 2; No. 1 being the lighter, and weighing thirty-eight Paris pounds. We could not come to any understanding about the weights made use of by Mr. Merz, and I believe Mr. Cranch had an idea of obtaining a set of such weights, if the identification of the glass, in any measure, depended on it; but I do not think it does. No. 2 was the heavier, weighing forty-two Paris pounds; but as no number or mark was apparent on either of the cells, we marked the heavier one No. 2, so as to preclude the possibility of our mistaking the one for the other. With a power of 336, the tube was now directed to the object, which was a small printed paper, of which Mr. Cranch will forward a copy, fixed against a building at the distance of five hundred and eighteen Paris feet north of our position. As I before observed, the agitated state of the atmosphere was extremely unfavorable to our object; notwithstanding, the few steady glimpses that I obtained, as the glasses were successively screwed into the object-end, convinced me that No. 2 was decidedly the better of the two; and this conviction, immediately on our leaving Mr. Merz, I communicated to Mr. Cranch, who I found had made the same observation.

The superior distinctness of No. 2 was so remarkable, that I suspected the cause to arise from a veiny structure in the glass of No. 1; and on placing the eye in the focus of the glass, having first removed the eye-piece, a very considerable number of veins were apparent. This, however, though a serious fault, and one from which No. 2, considering its magnitude, is remarkably free, was not the only cause of indistinctness, as our further trials on the following day most clearly proved.

Before leaving Mr. Merz, I ordered a ring and a disc to be prepared, the former to cover the circumferences, and the latter the central portions of the object-glasses, and they were prepared accordingly. The ring, when applied, reduced the aperture to nine and a half English inches, and the disc covered four and five eighths English inches of the diameter of the central part. These measures were not exactly according to the dimensions I had given, but they fully answered the purpose I had in view in employing them.

The afternoon of May 15th was propitious beyond all our expectations, and the examination was resumed and concluded. We compared the glasses with powers 336, 506, and 759, with the entire aperture of the glasses, and also with portions covered by the ring and disc above mentioned.

No. 1, when the aperture was reduced by applying the ring, was greatly improved in its general performance; but when the central portion was covered up, it was sadly deteriorated. I examined this matter with reference to the position of the veins, but had no doubt that imperfection of figure was the principal fault. On the other hand, No. 2 bore these tests in a most satisfactory manner; and as far as our means of examination allowed me to judge, it is my belief that this glass, both as to purity of material and excellence of workmanship, is of very superior quality indeed. I may just mention, that when we had concluded our examination, but before we had communicated our decision, Mr. Merz, pointing to No. 2, said, "We consider that the better glass of the two." I replied, that was our conclusion, and that there could be no doubt about it. He then further stated, that No. 2 was one of the two from which Professor Struve had selected one for Pulkova, and that it was then inferior to the one selected by the Professor, but that it had since that time been worked over again, and that he now considered it "better, very much better," than the Pulkova glass. However this may be, and I am by no means unwilling to believe it, certain it is, that it is indeed, considering its enormous magnitude, a remarkably fine telescope.

Having chosen the glass, Mr. Cranch regretted that he was not in a position to bring it away with him; for, as he very justly observed, it was most undesirable to leave it where there was another, to all external appearance, so exactly like it, that I doubted whether I could distinguish the one from the other without looking through them. Mr. Merz, at Mr. Cranch's request that he should write the name of the College upon the cell, proposed that it should be written on the edges of the two glasses, which he removed from the cell for that purpose. We then wrote upon the edges as follows: "Harvard College. W. S. J. C. May 15th, 1846," — with the point of a diamond; the crown and flint were both similarly inscribed.

If you should have occasion to remove the glasses from the cell, you will observe that three bearing-planes are left in the face of the cell, and that the glasses are cemented together at three equidistant points, having at those points plates of tinfoil inserted between them. Now you have to observe, in restoring the glasses to the cell, that these plates of tinfoil must be placed exactly over the bearing-planes upon the cell; but Mr. Merz informed us that it does not matter which plate is made to coincide with any given bearing. My own experience of object-glasses, however, inclines me to believe, that the glass will perform better in one position than in another, and it may be worth while to make this the subject of trial.

The removal of the glass from the cell was cleverly performed by Mr. Merz in the following manner. A circular-headed stool of about twelve inches in diameter was covered with some soft material, — leather or blotting-paper, I forget which. Upon this the interior glass was placed, the ring by which it is held within the cell having been first removed; the cell was then carefully drawn off, and the glass left upon the head of the stool. To replace it, the glass was first laid upon the stool, and the cell carefully slipped over it, with due regard to the positions of the bearings and tinfoil plates, before observed. The cell and glasses were then firmly grasped with both hands, the ends of the fingers entering the cell and pressing against the glass in order to support it; it was then lifted and carefully turned over, the face of the cell laid upon a table, and the ring and screws replaced. The screws were gradually tightened by passing the cell round several times.

And now, dear Sir, I believe I have only to add my earnest wish that the College may receive this magnificent instrument in safety, and reap a rich harvest of fame by its successful application.

Believe me, dear Sir, very sincerely yours,

William Simms.

To W. C. Bond, Esq., *Cambridge, U. S.*

## V.

### REPORT OF THE COMMITTEE APPOINTED BY THE BOARD OF OVERSEERS OF HARVARD COLLEGE FOR VISITING THE OBSERVATORY, FOR THE YEAR 1846-47.

*Read and Accepted*, 20 *January*, 1848.

THE subscribers, members of the Committee appointed by the Board of Overseers of Harvard University, visited the Observatory on the 21st day of September, and examined the telescope, now placed in position; they found the same perfect in all respects, and prepared for astronomical observations; they found also the other instruments in good order, and in their places, except the transit-circle, which it was stated would soon arrive, and complete the number required for the use of the Observatory.

DAVID SEARS,
ABBOTT LAWRENCE,
J. INGERSOLL BOWDITCH,
FRANCIS PEABODY.

*Cambridge, September* 21*st*, 1847.

### *Letter from the Chairman of the Committee, Hon. J. Q. Adams, to the Hon. Edward Everett, President of the University.*

Quincy, 27th October, 1847.

SIR: — I enclose herewith the Report to the Board of Overseers of Harvard University of their Committee, appointed on the 4th of last February, to visit the Astronomical Observatory, recently erected in intimate connection with the University, and to report its present condition.

The Chairman of the Committee and the Hon. Josiah Quincy, by the personal indisposition of the former, and other accidental occurrences, were disappointed of giving their attendance on the 21st of September, the day appointed for the visit of the Committee to the Observatory.

The majority of the members of the Committee, David Sears, Abbott Lawrence, J. Ingersoll Bowditch, and Francis Peabody, Esquires, met on that day, and after a personal inspection of the building, now completed, and of the admirable Fraunhofer equatorial, which seems like a visitant from distant worlds to reveal to us their hitherto undiscovered wonders, and after receiving interesting reports from the Director of the

Observatory, and from the Perkins Professor of Mathematics and Astronomy, prepared the Report of the Committee herewith enclosed, to be presented at the next meeting of the Board of Overseers.

Mr. Adams and Mr. Quincy, some days after the visit of the Committee, separately visited the Observatory, and, in company with yourself, inspected the buildings and the instruments in their present state.

They concur in the report of the Committee, which is hereto annexed, together with the reports of the Professor of Astronomy and Mathematics, and of the Director of the Observatory. And they trust they do not transcend the duties of their commission in earnestly recommending to the Board of Overseers, and to the Legislature of the Commonwealth, the continued parental protection and patronage of the University.

There is yet one instrument of extraordinary power for astronomical observation, long since ordered, but still to be received before the apparatus of observation will be complete. We may hope the annual report of the Committee of the Board of Overseers for the next year may announce it as an event consummated. In the mean time, we venture a few suggestions for consideration.

The establishment of an Astronomical Observatory for continued recorded observation of the phenomena of the heavens, in immediate connection with the University, presents itself in a twofold aspect, for the exercise of the superintending authority of the Board of Overseers, and the more comprehensive power of the Legislature of the State. The authority of the Board of Overseers is merely administrative, and it can take cognizance of the Observatory and its management only as of one department of the circle of sciences which it is the object of the University to familiarize by instruction to the educated children of the land. But an Astronomical Observatory, independent of its connection with the University, is of itself an object of deep interest to the Legislature, and to the people of this Commonwealth. An Observatory is a standing testimonial to the progress in the career of civilization of the people on whose soil it is located. It is more, — it is, by the purposes to which it is devoted, a temple hallowed to the worship of the Creator, raising the souls of all who are admitted to its nightly disclosures to a more intimate communion with the Author of the Universe, and with the ever-multiplying wonders of his creation.

Among the writings of Thomas Shepard, one of the earliest and most eminent founders of the churches of New England, was a discourse on the parable of the Ten Virgins; and that same parable may furnish an instructive image of a lamp committed to our hands to spread the light of Science on all our region round.

We therefore respectfully propose to the Board of Overseers, that, on their appointing their Committee on the Observatory for the ensuing year, they should add to the appointment a resolution charging the Committee, in consultation with the President of the University, the Professor of Astronomy and Mathematics, and the Director of the Observatory, to prepare and report to the Board a plan for the occupation and employment of the Observatory in both its capacities as a constituent department of the University, for the instruction of youth, and as one of the watch-towers of human science erected by a spontaneous and sympathetic consent of civilized nations, to extend by constant observation and calculation the knowledge of the physical universe. Such a plan, modified as it may be by the wisdom of the Board of Overseers, seems indispensable to vivify and animate with an active principle of usefulness the new instrument of human improvement committed to our charge; and should it meet the approbation of the Board, may, by the ultimate co-operation of the popular branch of the State Legislature, be shaped into a statute of the Commonwealth and of the University, which shall manifest the unabated adherence to the Pilgrim principle which presided at the foundation of Harvard College, and admonish our children of after ages, that the blessings heaped upon them during successive centuries since the first settlement of the country, by the unceasing and provident care and affection of their forefathers, impose upon them the corresponding duty of making like provision for their own posterity.

And finally, as this is in all probability the last opportunity that will be indulged to the Chairman of this Committee to report to the Board of Overseers on the condition and prospects of this new instrument of power, added to our most ancient seminary of learning, I would with my last words repeat, that, to its effective usefulness to the cause of science, of our country, and of the human mind, the patronage of the Legislature will be required. An annual course of Lectures upon practical Astronomy, including the history of the science, ancient and modern, its connection with Optics and Mathematics, Geometry, Geography, and Navigation, the construction of instruments used to assist the organs of vision, the description and uses of the several instruments, and the art of using them, might become a part of the instruction to be communicated to the students of the University, and it would be very desirable that a select number, say of five from each class, to be selected by the President and Fellows of the Corporation, should be assigned to take part as assistants in turn for the nightly observations of the Director of the Observatory. I trust they would consider it rather as a privilege extended to their voluntary acceptance, than as a burden added to their duties. And I cannot forget that a permanent provision is yet to be made, by the liberality of the Legislature, for the compensation and support of the Observator, the living soul, of which the cloud-capt tower, and the equatorials and prime-verticals and mural and refraction circles, are but the lifeless mechanical instruments, like the sword of the patriot in the hand of the warrior.

I am, with the highest respect, dear Sir, your friend and servant,

JOHN QUINCY ADAMS,
*Chairman of the Committee of the Board of Overseers of Harvard University on the Observatory, appointed 4th February,* 1847.

---

### *Letter addressed to President Everett, by W. C. Bond.*

Observatory at Cambridge, 26 July, 1847.

DEAR SIR: — I take great pleasure in complying with the request which you made during your last visit to the Observatory, that I should prepare for you a brief account of the large refracting telescope, which has recently been placed within its walls.

The construction of this instrument was intrusted to the eminent opticians and mechanicians, Messrs. Merz and Mahler of Munich, in Bavaria, the successors of the celebrated Fraunhofer. . . . . .

I omit the details of mounting the telescope, as they are of little general interest, and will be given in my Report to the Visiting Committee on the Observatory. By that time I hope to be able to add to them an account of the new transit-circle, which Mr. Simms has nearly completed.

After adjusting and securing the various parts, the whole was found to move freely and steadily under clock-work, it being well balanced in all its parts, and the friction greatly reduced by a judicious arrangement of counterpoises and friction-wheels. . . . . .

In regard to the ultimate capabilities of our telescope, we cannot be expected, from so short a trial, to have formed any very decisive opinion. It has, however, even under the disadvantage of a bad state of the atmosphere, exceeded our expectations. We have had the best opportunities for making observations during the early morning hours.

Of the close double stars, our attention was first directed to $\epsilon$ Coronæ. The components appeared round, small, and well separated; the difficult double star $\gamma$ Coronæ, which Captain Smyth ranks in his "Cycle" as "the Præses of Struve's vicinissimæ," was well separated, a dark space appearing between the principal star and its satellite. On the morning of the 20th of July, the companion of $\gamma$ Andromedæ was also well separated; the line micrometer gave a distance of three tenths of a second. I was surprised to find, on following this object into daylight, that our measures of distance could be taken after sunrise. I measured alternately with my son, both in distance and position, while the sun was shining on the telescope, and we both thought that we saw them full as well, or rather better, after sunrise than before. This might be owing to a quieter state of the atmosphere consequent on a rise of the thermometer.

On the evening of the 15th of July, the nebula No. 27 Messier, commonly known as the Dumb-bell Nebula, exhibited a great number of points of light, with a few larger stars, which were probably accidental, or not belonging to it, scattered over its surface. Three observers were confident of the resolution of this nebula. It occupied considerably more space than the field of the telescope would take in, and the form by which it has hitherto been distinguished was entirely lost; there appear, however, to be two centres of condensation. On the same evening *α* Lyræ was examined. It showed a small round disc, but the troubled state of the atmosphere rendered it unsteady; thirty-five stars were counted in the same field with it. The ring nebula of Lyra was beautifully shown. My friend, Hon. William Mitchell, who was observing with us, was confident that he saw many stars within the compass of the ring.

The companion of Antares, discovered by Professor Mitchell of Cincinnati, was quite conspicuous, notwithstanding the tremulous state of the atmosphere at the low altitude of the star.

The great nebula in Andromeda has a strong central point closely resembling a star. I do not recollect to have seen any notice of this. On examining the moon near the quadrature, the light is so exceedingly vivid, when the whole aperture of the object-glass is used with a power of 180, that it becomes painful to the eye. With higher powers, the mountains are brought out in bold relief, and the depths are opened.

On the evening of the 20th, having a friend with me who takes a strong interest in these matters, we were examining the moon along the boundary of light and darkness, and saw what had every appearance of being the effect of atmospheric refraction. The deep, black shadows of the rugged mountain-tops, stretching far across the plains until they were lost sight of in the unilluminated portion, enabled us by contrast to distinguish what seemed to be the first gray tint of dawn, and to trace the gradually increasing light to the full splendor of midday.

But I must recollect that you require of me only a brief account of our telescope. The objects revealed to us by this excellent instrument are so numerous and interesting, that it is difficult to know where to stop.

With the highest regard and respect, I remain, dear Sir, yours sincerely,

W. C. Bond.

To President Everett.

## *Report of the Director to the Committee on the Observatory.*

### 1847.

DURING the past year the work which has principally engaged our attention has been the reduction and publication of the moon-culminations, eclipses, occultations, and miscellaneous astronomical observations, made in former years. These include five hundred and thirty-eight moon-culminations, nine solar eclipses, several eclipses of the moon, one hundred and thirty-six occultations of fixed stars and planets, micrometric measurements made during solar eclipses, and differential observations on Mercury and Neptune, and the comets of June, 1845, February, 1846, May, 1846, March, 1847, and July, 1847.

Through the liberality of the American Academy, the printing of the results of these reductions has been completed to July, 1846.

The mass of meteorological and magnetical observations which have been accumulating since the establishment of the Observatory remain only partially reduced. The mean monthly and yearly results of the former have been published in the American Almanac.

The astronomical observations of the last year, up to September, 1847, have already been reduced, and they are now ready for the press; they comprise meridian observations of stars, moon-culminations and occultations, observations of the comets of March and July of the present year, and of Neptune at its quadratures and opposition.

The more immediately interesting results have, from time to time, been forwarded to the Royal Astronomical Society at London, and to the Editor of the *Astronomische Nachrichten*, at Altona, and published in the respective journals.

The magnetic apparatus has been kept in order, but only occasionally made use of. Tables of the moon's parallax in right ascension, adapted to this latitude, commenced by Professor Peirce, have been completed by my Assistant, Mr. George P. Bond, and those for declination have been commenced by the latter. He has likewise computed circular elements of Neptune, and elements of the comets of March and July of this year, and an ephemeris for the expected return in 1848 of the comet of 1556.

It has been with much pleasure that the Director has noticed an increased interest in the collection of books for the library of the Observatory. The importance of having such a library can hardly be too much insisted upon; the contributions to it have already become frequent and valuable. A list of recent donations is subjoined.

Since the last annual visit of the Committee, important additions have been made to the apparatus of the Observatory.

The grand refractor has been received in perfect condition, and mounted without accident upon its noble pier; thus far we have reason for congratulation that all the internal arrangements of the dome, and everything connected with this superb instrument, are in due proportion. The machinery for turning the dome, and for opening and closing the shutters, is found to work with all the ease and expedition which could be desired. The parallactic mounting of the telescope arrived at the Observatory on the afternoon of Friday, June 11th, 1847. It came packed in thirteen large cases, which, together with their contents, were estimated to weigh about six tons. In order to facilitate the mounting or putting together the parts of this instrument, I had caused a strong platform to be erected at a convenient height round the stone pedestal, with proper framework, blocks, and tackle. To guide the stone-cutters in giving the right inclination to the top surface of the granite pedestal for the reception of the massive bed-plate of the equatorial, a triangle of wood was constructed, having such a relation between its sides, that a plumb-line and level attached would always indicate the required inclination.

On the morning of the 12th of June, the cases were opened, when, upon careful examination, everything appeared to be in as good condition as when packed at Munich. As soon as the stone was prepared for the reception of the instrument, a work which occupied the time until the 22d, the cases were arranged in their proper order round the hall of the dome; the case containing the great tube was placed on the staging on the north side of the pier, in a horizontal position; those containing the bed-plate and plate of the polar axis were raised to the platform, and placed in a convenient position. The following order was observed in putting the parts together, after they had been all carefully cleansed and oiled.

1st. The bed-plate, being screwed home on the stone support, was found to have an even bearing through its whole length.

2d. The large plate for the polar axis to rest upon was secured to the bed-plate by its four home and four abutting screws.

3d. The endless screw of the hour-circle, with its adjusting pieces, was then screwed on.

4th. The brass tube of the declination axis, and the hour-circle, were then secured to the polar axis.

5th. These were together raised to their position and gently lowered into place, and then secured by bridges.

6th. The tube of the declination axis was firmly fixed in a horizontal position.

7th. The cradle for receiving the tube of the telescope was fastened to the declination axis, and the roller-circle put on.

8th. The declination axis, cradle, and roller-circle were raised to their position.

9th. The clamping and declination circles, the arms for the verniers, the clamp-work and steel friction-circle were adjusted, and secured by the great screw-nut at the end of the declination axis.

10th. The lengthening-piece and balance-weights, the fork, and counterpoise weights of the polar axis were put on, and the whole was then permitted to come into the position of gravity.

11th. The great tube was placed in its cradle, and secured by its bridges.

12th. The long counterpoise arms, with their weights, fastened to the tube.

13th. The finder telescope was screwed on, and the object-glass placed in its cell.

14th. The various counterpoising weights were adjusted, when the whole was found to move with ease and steadiness.

The whole work was completed without the slightest accident, and without having to retrace a single step. This was, no doubt, in some measure to be attributed to the precaution that was taken previously to commencing operations, to understand clearly the design and proper position of each separate piece.

In the afternoon of the second day, the telescope was directed to the moon, then low in the southeastern quarter of the heavens; the excellent definition assured us that the object-glass had sustained no injury.

The more delicate adjustments of this instrument have of course occupied much time. Some additions which were considered expedient have been made, among them an adapting piece whereby the double-image micrometer, the gift of William Shimmin, Esq., has been made available with this instrument.

After a full and satisfactory trial, we now feel prepared to speak decidedly as to the capability of this instrument. The primary chromatic dispersion of the object-glass is well corrected. The definition is such as to present those most difficult test-objects to which a telescope can be directed, namely, double stars of less distance than half a second of arc, as small discs separated by a dark interval. As particular instances, we may mention the stars $\gamma$ Coronæ and $\gamma^2$ Andromedæ, both of which, in favorable states of the atmosphere, our telescope easily separates. Practical astronomers will ask no further proof of the excellent quality of the object-glass.

In the examination of nebulæ, it has opened to us a rich and extended field of research; we may cite, as instances, the new and interesting features disclosed in the great nebula of Andromeda, than which no object in the heavens has hitherto yielded less to increase of optical power. The resolution of the nebula No. 27 Messier into points of light, is sufficient evidence of the space-penetrating power of the instrument.

A comet-seeker of the best description has recently been presented by J. I. Bowditch, Esq., of Boston. A more acceptable and useful addition to our apparatus could not have been made; it is from the same establishment as the great refractor, and proves on trial to be admirably adapted to the purpose for which it was intended. By a convenient arrangement, it was mounted during the present month in the same building with the great equatorial, thereby enabling the Observer to command an unobstructed horizon, and a ready communication with the large instrument.

I had intended to have given, with this Report, a full and minute description of the great refractor; but on further consideration it seems better to defer this until the Observatory has been completed by the reception and mounting of the transit-circle now in the hands of Messrs. Troughton and Simms. This instrument is so nearly finished, that, but for an accident which delayed the work, it would probably have been received before this time.

Respectfully submitted,

W. C. Bond.

To the Hon. John Quincy Adams, Hon. Josiah Quincy, Hon. David Sears, Hon. Abbott Lawrence, J. I. Bowditch, Esq., R. T. Paine, Esq., Francis Peabody, Esq., *Committee for visiting the Observatory.*

*Cambridge, September 21st,* 1847.

---

### *Letter addressed to President Everett, by W. C. Bond.*

Cambridge Observatory, 22d September, 1847.

Dear Sir: — You will rejoice with me, that the great nebula in Orion has yielded to the powers of our incomparable telescope!

This morning, the atmosphere being in a favorable condition, at about three o'clock the telescope was set upon the Trapezium in the great nebula in Orion. Under a power of 200, the fifth star was immediately conspicuous; but our attention was very soon absorbed with the splendid revelations made in its immediate vicinity. This part of the nebula was resolved into bright points of light. The number of stars was too great to attempt counting them; — many however were readily located and mapped. The remarkable character of the star $\theta$ in the Trapezium was readily recognized with a power of 600. The companion, "Struve's sixth star," was distinctly separated from its primary, and certain of the stars composing the nebula were seen as double stars under this power.

It should be borne in mind, that this nebula and that of Andromeda have been the last strong-holds of the nebular theory; that is, the idea first suggested by the elder

Herschel of masses of nebulous matter in process of condensation into systems. The nebula in Orion yielded not to the unrivalled skill of both the Herschels, armed with their excellent reflectors. It even defied the powers of Lord Rosse's three-foot mirror, giving "*not the slightest trace of resolvability*"; by which term is understood the discerning *singly* a number of sparkling points. And even when, for the first time, Lord Rosse's grand reflector of six feet speculum was directed to this object, "not the veriest trace of a star" was to be seen. Subsequently, his Lordship communicated the result of his further examination of Orion in the following words:—

"I think I may safely say, that there can be little if any doubt as to the resolvability of the nebula. We could plainly see that all about the Trapezium is a mass of stars, the rest of the nebula also abounding in stars, and exhibiting the characteristics of resolvability strongly marked."

This has hitherto been considered as the greatest effort of the largest reflecting telescope in the world, and this our own telescope has accomplished.

I feel deeply sensible of the odiousness of comparison, but innumerable applications have been made to me, for evidence of the excellence of the instrument, and I can see no other way in which the public are to be made acquainted with its merits.

With sincere respect and esteem, I remain, dear Sir, your obedient servant,

W. C. Bond.

To President Everett.

## VI.

## Report of the Committee appointed by the Honorable and Reverend the Board of Overseers of Harvard University, to examine the Observatory, for the Academic Year 1847–48, with the Accompanying Documents.

*Read and Accepted*, 7 *February*, 1849.

The Committee appointed by the Board of Overseers of Harvard University, in February last, for visiting the Observatory connected with that institution, respectfully report, that they met at the Observatory, in Cambridge, on the 15th of November last, all the members of the Committee being present except Mr. Lyman, who is in Europe; Mr. Adams, the Chairman of this Committee, having deceased since their appointment.

The Committee proceeded to examine the several departments of the Observatory, and to view the instruments, particularly the great refractor, which they found in good order, perfect in all respects, and having now been in position and daily use for more than a year. The Committee are happy, after this adequate test, from experience, to speak of it as equalling, in point of power and facility of adaptation to astronomical researches, all the hopes of its subscribers, and even exceeding their highest expectations; and as justifying the opinion, that it is inferior to none, and equalled by not more than one or two, in the world.

Your Committee also had the satisfaction of examining the long-expected transit-instrument from Great Britain, which has been recently placed in position, and, in every respect, promises to fulfil the most sanguine hopes of the friends of the institution.

The Observatory may now be regarded as possessing the two most essential instruments for accurate astronomical observations of the highest character; and from its elevation, and almost wholly unobstructed horizon, embracing the most satisfactory local advantages.

At this meeting the Director of the Observatory communicated a report, in which, after expressing his satisfaction with the promise of the transit-circle, then recently mounted, and his hope that it will be very perfect of its kind, he proceeds to detail the celestial objects to which his attention has been directed during the past year, and the results of his observations on those objects; concerning which the Committee will only observe, that their number, their variety, their wise selection, and the laborious zeal with which his investigations have been pursued, do the highest credit to the Director's unceasing industry and scientific attainments. His report is hereto subjoined. Appended to this Report is a "Description of the Instruments and of the Observatory," which is stated to be accompanied by "ground-plans and plates, representing sectional and prospective views of the apartments and principal instruments." This description is clear and exact in its details, and is highly important and necessary to give to the public a knowledge of the nature, quality, and power of the respective instruments, and of all the circumstances which combine to show the adaptation of the institution to its objects, evidencing the success with which the noble and patriotic designs of those who projected this Observatory have been prosecuted and completed.

It is to be regretted that this description should in so great a degree be deprived of its usefulness and interest, by being deficient in those *plates* to which it continually and unavoidably refers. It is obviously essential that descriptions of this kind, and generally of all astronomical results, should be illustrated and explained by appropriate *engravings*. The want of them deprives the institution of the only complete means by which the progress of the Observatory, and the results of the observations of its Director, can be satisfactorily communicated to the public, and to the scientific world both in Europe and America. This want is at present the most pressing and essential to give extension to the usefulness and a general knowledge of the results of the Observatory. All the great wants of the institution, its great refractor, its transit-circle, and its subsidiary instruments, have been supplied by the labors and liberality of individuals and literary societies. Through the munificence of a single individual, recently deceased, an ample fund has been provided for the salaries of the Observer and his Assistants.

All these great results, in their nature altogether public, and redounding to the honor of our Commonwealth, have been effected by private exertions and liberality, without any public patronage or contribution whatsoever. The printing also of the descriptions and results of these astronomical researches is defrayed out of the funds of the American Academy of Arts and Sciences, *which, however, do not enable them to defray the expense of these and such like engravings.* Under these circumstances, is it too much to hope, and to ask, of the enlightened Legislature of Massachusetts, by an annual appropriation of a sum *not exceeding five hundred dollars*, to provide for defraying the expense of all such plate illustrations and engravings of the state of the Observatory, and of the results of the observations of its Directors, as the Committee of the Observatory, or the American Academy, by publication in their Memoirs, shall sanction? Your Committee cannot but believe that, when these wants are known, and their nature considered, they will be met and provided for in a liberal spirit by the Legislature of Massachusetts.

In the course of their inquiries, your Committee have ascertained that the instruments connected with the Observatory, and under the care of its Director, have been derived from various sources, some of them having belonged to the University antecedent to the establishment of the Observatory; others have been obtained from private munificence, others are the property of Mr. Bond, and others again of the American Academy of Arts and Sciences.

Under these circumstances, your Committee deem it proper to suggest, that an inventory of the astronomical, magnetical, and meteorological instruments, stating the sources from which derived, and to whom, at the time, they may belong, should be annually prepared, and submitted to the Visiting Committee, whose duty it shall be to inspect the several instruments, compare them with the inventory, and report their actual state and the result of their inquiries to the Board of Overseers.

On this occasion, your Committee have the satisfaction of congratulating the public and the friends of the institution on the power and skill manifested by the Director of the Observatory, in the very difficult and delicate task of placing the great refractor and transit-circle in position, in the happy adaptation of the machinery for moving the dome, and in arranging and preparing the equatorial, the transit-circle, and prime-vertical rooms; in all which his judgment has been called into exercise, and in general been conclusive.

It is not here necessary to notice the fidelity, talent, and laborious zeal with which he has fulfilled the duties of his office, in daily and nightly watching of the heavens, which the results already published by him abundantly evidence. Among which it is proper, on this occasion, to notice the discovery of *an eighth satellite of the planet Saturn*, made by Mr. Bond, at the Observatory in Cambridge, on the 19th of September, it being *the only addition to the solar system ever made on the continent of America.* And although, by a singular coincidence, Mr. Lassell, a British astronomer, discovered in his country the same satellite on the very same day on which it was discovered here by Mr. Bond, the circumstance in no degree detracts from the merit of Mr. Bond; it being agreed by British astronomers themselves that there is no pretence of priority in favor of either, but in fact the discovery was contemporaneous; and they propose that it should be called, in Great Britain, the discovery of Mr. Bond and Mr. Lassell, and in America, the discovery of Mr. Lassell and Mr. Bond.

With like feelings of approbation, your Committee cannot refrain from speaking of the talent and unwearied industry displayed by Mr. Bond's Assistant and son, George P. Bond, in the execution of the duties of his office. The many results of his labors have, from time to time, been communicated to the public. It is, however, due to him in this place to state, that, out of *nine* comets discovered in this country, before any information was received of their discovery in Europe, *seven* were discovered by George P. Bond; an *eighth*, by Miss Maria Mitchell, of Nantucket, to whom the medal offered by the king of Denmark has been awarded; of the *ninth,* Hamilton Smith, of Cleveland, Ohio, has the merit of the discovery.

From their own reflections, as well as from the suggestions made by their late chairman, John Quincy Adams, in a letter dated the 19th of May, 1843, addressed to the President of the University, and heretofore communicated to the Board of Overseers, your Committee deem it their duty earnestly to press upon the Corporation of the University the expediency, by distinct and authoritative votes, of designating the person in whom the care, control, and responsibility of the Observatory, and of the instruments connected with it, are invested. The present moment, when the most perfect harmony and good understanding exist among all those who, in any of their relations, are connected with the Observatory, seems peculiarly auspicious for such a designation.

On this point your Committee deem it their duty, unanimously, to state, that in their judgment the occupation, care, and custody of the house and buildings, and of all the instruments connected with the Observatory, should be vested *in the Director of the Observatory for the time being*, and that on him should rest, exclusively, the responsibility for their use, by himself, or any person whatsoever; and that also the right in the observations made by him shall vest in him exclusively, to be communicated to the public when and in what form he pleases; subject always to the direction and control of the Corporation of the University, in respect of the occupation of the house, buildings, and land connected with the Observatory, the tenure by which they are holden, the use of the instruments, by himself or others, and the time and mode of making public the results of his celestial observations.

At this meeting your Committee had the benefit of the presence of the President of the University, and of Mr. Peirce, the Perkins Professor of Astronomy and Mathematics, who favored the Committee with a report, in which he states the results of his investigations into the theory of the planet *Neptune*, and his researches into the theory of its action upon the planet Uranus, and the coincidences and differences of his views from those of Messrs. Adams and Leverrier; "names," Mr. Peirce adds, "which, from the grandeur of their triumphs in science, entitle them to be inscribed in the rolls of the greatest of geniuses."

In this report Professor Peirce announces his being engaged in preparing a large treatise upon Analytical and Celestial Mechanics, in which he intends "to incorporate the investigations of previous geometers, and to make such additions as he may be able to achieve."

It is impossible for your Committee, in closing this Report, to refrain from noticing the loss the public, and particularly Harvard University, have sustained by the death of the late John Quincy Adams, who for many years occupied the place of Chairman of this Committee, and who was second to no individual of his time in zeal, and in efforts to advance the cause of astronomical science. The records of this University, as well as those of the national government, abound in evidences of the depth and earnestness of his attachment to this science, and of his assiduous endeavors to establish Observatories in the United States. . . . . .

It was the interest universally known to be taken by him in the establishment of Observatories in the United States, which led the inhabitants of Cincinnati to invite Mr. Adams to come from Massachusetts, to assist in laying the corner-stone of an Observatory they were about to erect in that city. The oration he delivered on that occasion remains an enduring monument of his zeal for the advancement of the science of astronomy, and of the depth and extent of his researches into its nature and history.

The same patriotic anxiety led him, in December, 1825, when President of the United States, in his annual message, to recommend to Congress the establishment of a

National Astronomical Observatory; representing it as a national reproach, that, while *one hundred and thirty* of those institutions existed in Europe, not one existed, at that time, in the United States. The result is well known. The recommendation received no support or countenance from Congress, and was met with ridicule rather than respect. Mr. Adams was neither discouraged nor disheartened by the treatment he received. Persevering in his purpose, when, as Chairman of the Committee of Congress on the Smithsonian Bequest, he submitted, in January, 1839, for the consideration of that body, a resolve that the first appropriation from the interest and means of the Smithsonian Fund ought to be for the erection and establishment, at Washington, of an Astronomical Observatory. Although this recommendation received no support from Congress, in March, 1840, being then also Chairman of the Committee on the Smithsonian Fund, he urged with eloquence, and in great detail, arguments in favor of establishing an Astronomical Observatory out of that fund, and reported a bill containing a section especially providing for its establishment.

Although none of these reiterated attempts of Mr. Adams received the open sanction of Congress, his zeal and his eloquence produced their natural effects. A disposition to found a National Observatory began to prevail in that body, united with a determination, if possible, to disconnect its establishment from the name and influence of Mr. Adams. To this end large annual appropriations, for a series of years, were made for the Navy Department. Objects to which the appropriation might be applied were carefully enumerated, and a clause was inserted annually that the appropriation should be applied to the objects enumerated, and *to none other. Among these a National Observatory was not included,* some members of Congress declaring their determination to vote against the appropriation, if the name of an Observatory was included among its objects. Yet, in direct defiance of these declarations and this statute prohibition, thus express and exclusive, Congress permitted annually this appropriation to be applied to the establishment of an Observatory, which now bears the title of National, notwithstanding it was apparently erected, not only without the authority of Congress, but in direct violation of an express provision of its statutes. Although, by this course of proceeding, that institution was temporarily separated from the name and influence of Mr. Adams, the facts remain on record and in memory. History will be faithful, and the name of John Quincy Adams will be transmitted to posterity as the first to recommend to the Legislature of the United States the establishment of a National Observatory, and who by unceasing efforts, during a series of years, so inspired Congress with a disposition favorable to his purpose, as finally to effect the object; — entitling him to be regarded in all future times as *virtually the founder* of the Observatory at Washington.

On this occasion your Committee submit this recapitulation and detail of facts, due to the memory of Mr. Adams, and in strict connection with the objects of this Report.

By order of the Committee,

JOSIAH QUINCY, *Chairman.*

*January*, 1849.

---

## *Report of the Director to the Visiting Committee of the Board of Overseers of Harvard University.*

1848.

GENTLEMEN: — I have the pleasure of announcing to the Board of Visitors the receipt of our transit-circle. It has been mounted without accident; and from the cursory examination which we have been enabled to give it, there seems no reason to doubt that it will prove worthy of the high reputation of its maker, who, I have good reason to believe, has exerted himself to furnish us with as perfect an instrument as it was in his power to produce.

As this instrument completes the apparatus with which it was originally intended to furnish the Observatory, it is now proposed to append to this report a description of the instruments and Observatory, accompanied by ground-plans and plates, representing sectional and perspective views of the principal rooms and instruments.*

During the past year, the series of moon-culminations and transits of stars over the meridian has been continued, and the observations have been reduced as far as the last of September. Copies of these observations are furnished to Dr. Bache, as heretofore, for the use of the United States Coast Survey.

Transits of stars over the prime-vertical and occultations of stars by the moon have been observed in connection with similar observations made at the Coast Survey stations at Agamenticus in Maine and at Nantucket.

The physical condition of the sun's disc has been attended to whenever the state of the atmosphere has admitted of distinct delineation. Some experiments made with the Daguerreotype and Talbotype processes, for the purpose of obtaining impressions from the image formed by the telescope, have not been attended with complete success. The application of these processes to astronomical purposes is met by a serious difficulty in the variable refraction of the atmosphere. However, we do not despair of ultimate success, when our time and means are adequate to the requisite expenditure.

---

* See Description of the Observatory.

The Royal Astronomical Society of London has invited the attention of astronomers to the prosecution of a regular series of observations of this kind, to be made at certain periods. Our drawings, now numbering more than two hundred, may, from the geographical position of the Observatory, possess some interest.

The search for comets has been persevered in during favorable nights. It has been a rule with the first Assistant to complete the sweep of the whole visible heavens once every month.

The comets on which observations have been made are Mauvais's of July, 1847, Miss Mitchell's, and Encke's. The former was followed from July 14, 1847, up to April 21, 1848. This is probably the longest period of visibility of a telescopic comet on record. Sufficient observations of Miss Mitchell's comet were obtained to determine a near approximation to its true elements. Encke's comet was first seen at this Observatory on the morning of the 27th of August. Observations on it have been frequent, and are still in progress.

The study of the physical aspect of the planet Jupiter and his satellites has engrossed much of our attention, and has been conducted under circumstances highly favorable. Communications on this subject have been made to the American Academy, which have been published in the Proceedings of that body. It is proposed to prosecute these examinations on the reappearance of Jupiter, before reporting definitively on the results. The measures of the equatorial and polar diameters of this planet seem to favor the conclusion, that the received amount of its ellipticity requires correction.

Our attention has at times been directed to the transits of the satellites across the disc of the primary, and to their comparative brightness at different times. A remarkable phenomenon, which has often presented itself, deserves particular notice. It is this. We have frequently seen the third satellite, after its ingress with its usual brightness upon the limb of Jupiter, suddenly transformed into a dark spot, and in that state traverse the disc of Jupiter, until it approached the point of egress, when it has resumed a considerable portion of its wonted illumination. Similar changes have attended every transit of this satellite which we have witnessed during the year. Transits of the other satellites have been observed, but they have not presented any analogous appearance. This curious fact is not altogether new; but it has probably never before been witnessed under equally favorable circumstances, and appears of late years to have been wholly lost sight of.

Our records of the comparative brightness of the satellites indicate marked changes in their relative brilliancy, *each having in turn* varied from being the brightest to being the faintest. The whole subject cannot but be considered as worthy of careful investigation.

The satellite of Neptune has been regarded as an object of peculiar interest, on account of its affording the only data within our reach for computing the mass of the primary. To obtain accurate measurements of so faint an object, requires a combination of circumstances but rarely occurring. It has therefore been our endeavor to miss no favorable opportunity of determining the relative positions of the primary and satellite.

From a desire of avoiding the error of wasting our resources in cursory examinations of a great number of interesting objects, we have rather sought to confine our attention to a few, and to give these few a thorough investigation. With this purpose, in the department of nebular astronomy, we have given a large share of attention to the nebulæ of Orion and Andromeda. The details of our mode of proceeding, and the results of our examinations, together with a paper by my son, giving some methods of computing the ratio of the distances of a comet from the earth, were communicated to the Academy, and have recently been published in their Memoirs.

Some progress has been made in the formation of a catalogue of double stars. As a general rule, the most interesting binary systems already known, and the most difficult double stars, have been selected; the latter with a view to test the capabilities of the great refractor in this class of observations.

While observing the minute companion of Procyon, it was noticed that *three* stars of the seventh and eighth magnitudes were missing from its vicinity. Bessel's Zone, Hora 7, No. 52, has a double star of the seventh magnitude, the position of which, compared with Procyon, is 130° south following, at the distance of 230″. At present neither of the components of this double star is seen; the nearest at present visible is Piazzi VII. No. 170, which is identical with Struve's No. 1126. Again, Smyth in his "Celestial Cycle," p. 182, gives the angle of position and distance from Procyon of an orange-tinted star, of the eighth magnitude, as follows: — Position, 85°; distance, 145″. This star has also disappeared.

These facts, considered in connection with the reported inexplicable proper motion of Procyon, are sufficient inducements for us to watch the neighborhood, in future years, carefully.

On the 28th of April of the present year, Mr. Hind, of the Observatory in Regent's Park, London, discovered a new star, which, by his earliest observations, was of the fourth to fifth magnitude; by us it has never been seen brighter than the sixth magnitude. On the 28th of September, it was hardly above the eighth magnitude. Its color is a fine deep red; within a radius of six minutes of arc of this star, our telescope shows thirty companions of from the fifteenth to the twentieth magnitudes. We have watched the position of Hind's star by continued measurement from a star of the fifteenth magnitude in its vicinity, with a view of detecting its parallax, if sensible, or rather of establishing a limit which it does not exceed.

The planet Saturn during the present year is an object of particular interest, on account of the position of the plane of its rings, the edge being presented to the earth with very limited departures. It has afforded us a fine opportunity for examining the construction of the rings, and for watching the movements of the interior satellites, Mimas and Enceladus, so well described by Herschel as showing themselves for a short time, and then hastening to their habitual concealment.

We have been enabled to make a considerable collection of micrometric measures of the equatorial and polar diameters of Saturn, the rings, and the satellites. We have frequently seen the light of the sun reflected from the *interior* edges of the rings with sufficient distinctness to subject the different parts to micrometric measurements. The thread of light to which the ring was reduced, presented in the great refractor a phenomenon of very singular character. It not appearing continuous and uniform, but with inequalities resembling beads of light, which we have never seen to move relatively to the planet, although they have been watched during intervals long enough to exhibit very sensible changes in the positions of the satellites. The appearance is that of masses of matter attached to the rings; but if the rings have a rapid motion of rotation about the primary, they ought quickly to change their positions, which does not satisfy the observed conditions of the phenomenon.

Considering the close scrutiny to which this planet has been subjected, it is certainly a remarkable circumstance, that we should have detected an additional satellite, and have been followed so closely in the discovery by an observer in England.

We intend to follow up our observations on Saturn to the time of the reappearance of the ring to ordinary telescopes, and then to present our results to the Academy. Mr. George P. Bond has computed the orbit of the newly discovered satellite, and finds a periodic time of revolution of twenty-one days; he also finds considerable ellipticity in the orbit, and probably considerable disturbance from its near neighbor Titan.

During the past summer, the lines of the magnetic telegraph have been extended to this Observatory, and a series of transit observations have been gone through in connection with the United States Coast Survey, for the determination of the difference of longitude between New York city and this place. This work engrossed nearly all the time favorable for observation during the months of July and August; happily, the result has proved highly satisfactory.

The Meteorological Register, at four periods of the day, has been continued as usual. Copies of the monthly means of temperature, barometric pressure, temperature of the earth, quantity of rain, winds, clouds, &c., have been published in the American Almanac. We have frequent applications to examine this record, and for copies, and the same in regard to the variation of the magnetic needle.

It is a matter of some regret with the Director of the Observatory, that he has found it impossible to continue the course of magnetic observation.

We have commenced a work which seems likely to occupy a considerable portion of at least another season. It is the charting of the stars composing the cluster in Hercules. The south-following star of the central Trapezium has been adopted as a primary station, and the other stars are laid down from it by micrometric measures of angles of position and distance. The object is to acquire, if possible, some knowledge of the interior constitution of this cluster.

Respectfully submitted,

W. C. BOND.

TO THE HON. JOHN QUINCY ADAMS, HON. JOSIAH QUINCY, HON. DAVID SEARS, HON. ABBOTT LAWRENCE, J. I. BOWDITCH, ESQ., R. T. PAINE, ESQ., FRANCIS PEABODY, ESQ., *Committee for visiting the Observatory.*

*Cambridge, November* 15, 1848.

---

## VII.

## REPORT OF THE COMMITTEE APPOINTED BY THE OVERSEERS OF THE UNIVERSITY AT CAMBRIDGE TO EXAMINE THE OBSERVATORY, FOR THE ACADEMIC YEAR 1848-49, WITH ACCOMPANYING DOCUMENTS.

*Read and Accepted,* 7 *February*, 1850.

THE Committee appointed by the Board of Overseers of Harvard University, in February last, for visiting the Observatory connected with that institution, respectfully report, that a meeting of that Committee, duly notified, was held at the Observatory, early in November last, at which were present Mr. Quincy, Mr. Sears, Mr. Lawrence, Mr. Paine, and Mr. Bowditch, who proceeded to examine the great equatorial refracting telescope, and the other instruments and apparatus belonging to this interesting and important institution. All of which were found perfect, and in high order, with the exception only of the transit-circle, which was found to have sustained some injury after it had come from its maker's hands, either on shipboard, or by some accident occurring in its transfer from the vessel to the Observatory. This injury, although it did not affect its usefulness as a transit-instrument, rendered it not sufficiently accurate when employed as a declination-instrument. This defect will perhaps render it necessary to send the instrument to Europe for correction and adjustment. The other instruments, the apparatus, and the buildings connected with the Observatory, were found in every other respect in a highly satisfactory state; justifying that entire confidence in the ability, care, and judgment of the present Director of the Observatory, which have so often been expressed, and to which he is so justly entitled.

At this meeting the Director communicated to your Committee a report on the state of the institution, in which he detailed the operations which, during the past year, and since the meeting of your Committee in November, 1848, had chiefly engaged his attention, and in which he also expressed his perfect satisfaction with the great refractor, "which had enabled him to make some acceptable contributions to the general stock of astronomical science." He also therein states the nature of the injury done to the transit-circle, and the means he proposes to adopt to restore it to a perfect condition.

In this report the Director of the Observatory also states the practical uses to which the Observatory has already been applied, and the measures taken by him to make one of the transit-instruments of the Observatory to correspond with one which is mounted at the Coast Survey station near the city of Washington, "for the purpose of co-operating in magnetic-telegraph communication, through the wires which connect our Observatory with that station"; — also, the measures he has taken, at the instance of the United States Coast Survey, to ascertain, in co-operation with the Directors of other Observatories, by means of the magnetic telegraph, the difference of the meridians of certain points, situated in Cambridge, New York, Philadelphia, and Washington.

In this report the Director also states his views and labors in charting the stars of the cluster in the constellation of Hercules, with his motives in this undertaking. He adds a of list his publications, during the past year, with an account of a project, originating in his suggestion, now in successful prosecution, to ascertain, by means of chronometers transmitted from Europe, the difference of longitude of Greenwich and Cambridge, also in connection with the Coast Survey.

The measures put in train by him to effect this and other objects of astronomical science, the ready co-operation in his views by astronomers in Europe, the assistance given him by Mr. Hartnup, the Director of the Observatory at Liverpool, and that which he has also derived from the publications of Robert Treat Paine, Esq. in this country, are stated and appropriately acknowledged.

The evidence this report furnishes of the industry, ability, and devotion to the advancement of astronomical science of the present Director of the Observatory, cannot fail to increase the public satisfaction with the present and prospective usefulness of an institution, under the superintendence of an individual so well qualified and so zealously devoted to promote its interests.

Your Committee entirely concur with the opinion expressed by the Director of the Observatory, in relation to the expediency, if not necessity, of taking early measures for erecting a western wing to the Observatory. The importance of such an addition to it, for the purpose of making systematic observations in meteorology and terrestrial magnetism, cannot be too highly estimated, and the institution being now in a condition to furnish all the instruments necessary for such an establishment, it cannot but be greatly regretted that the want of a suitable building should alone be an obstacle to their use and application. Your Committee cannot but hope that early measures will be adopted for the erection of these requisite buildings, and means obtained for that object from private liberality, or from that of the public.

In connection with the subject of ascertaining the longitude of Cambridge, it has occurred to your Committee that there would be a fitness, and even a useful precision, if all the observations made by the great refractor should, when published, indicate *the exact geometrical point* where the instrument is fixed, by the name of the tower in which it is stationed, instead of embracing, as those publications now do, the whole town of Cambridge, or the whole extent of the Observatory. In making this suggestion, your Committee only desire to bring the subject under the consideration of the Director of the Observatory, and of those who have the general superintendence of the institution.

In compliance with the request of your Committee, Mr. Bond has prepared and transmitted "an account of the telescopes, time-keepers, various apparatus, and books at the Observatory," which, with his report on the general state of the institution, are hereunto subjoined.

The relief obtained for the ever-recurring wants of the Observatory, for the salaries of the Observers, for the annual supply of books and instruments, from the munificent bequest contained in the will of the late Edward Bromfield Phillips, is also appropriately acknowledged by Mr. Bond. A fund, amounting to one hundred thousand dollars, established by the provisions of his will, has already been received, the incomes of which are, exclusively, for ever hereafter to be applied to the objects above mentioned, in their nature absolutely essential to the success of the Observatory. In reference to this noble bequest, your Committee cannot refrain from expressing their sense of obligation and respect for the memory of a young man, who in the prime of life, and with no other anticipation of coming casualties than those incident to a voyage to Europe, had the public spirit thus prospectively to lay the foundation for the ample supply of the essential and never-ceasing wants of this important institution, and who has thus placed his name high in the ranks of the great public benefactors of literature and science.

Your Committee, taking into consideration the rapid and great increase of the means of this Observatory, and reflecting upon its natural popularity, and upon the evidence already given by the community to render it a permanent institution, have been impressed with an anxiety that nothing should be done which should in the opinion of the public, or of those disposed to be its patrons, have a tendency to limit or obstruct its power and usefulness. Under these impressions, your Committee are compelled to express a hope, that no more of the lands lying to the eastward of the Observatory lot, and which were purchased with reference to the establishment of the institution, should be sold, but retained for its future enlargement or wants, which, at no distant period, may be reasonably anticipated. Your Committee are aware of, and duly grateful for, the liberality with which the Corporation of Harvard College have applied their funds, for the advancement of the Observatory; and should, in their judgment, the sale of these lands become absolutely necessary, in respect of their claims on the funds of the Corporation, your Committee cannot doubt that such sales, if made, will be under restrictions as to the height and uses of the buildings to be erected upon those lands, and their exclusion from being used for mechanical purposes, so as to preclude, as far as possible, any injury to the atmosphere, or obstruction to the horizon, in respect of the Observatory.

All which is respectfully submitted, by order of the Committee,

JOSIAH QUINCY, *Chairman.*

*Boston, 23d January*, 1850.

---

## *Report of the Director to the Visiting Committee of the Board of Overseers of Harvard University.*

### 1849.

GENTLEMEN: — Since I had last the honor of meeting the Committee on the Observatory the operations which have chiefly engaged my attention have been the examination and micrometrical measurement of the planets Neptune, Saturn, and Jupiter, and their satellites, observations of comets, double stars, clusters, and nebulæ, occultations of stars by the moon, meridian transit observations, the determination of differences of longitude of certain points within the United States by aid of the electro-magnetic telegraph, and the difference of longitude of Greenwich and Cambridge, by chronometers transmitted in the steam-packets plying between Boston and Liverpool.

A meteorological journal is kept at four periods of the day, and occasional magnetic observation, for the comparison of instruments to be used on distant surveys.

The usual number of transits of stars are recorded; but as it was found, on examining our collection of data, that we had amassed a much greater proportion of moon-culminations than of eclipses and occultations, for the longitude of our position, we have deemed it advisable to discontinue the moon-culminating observations for the present. When the data by the other methods are brought up to a near equality, they will be resumed.

Occultations of stars by the moon are never neglected; the observation of them is much facilitated by Mr. R. T. Paine's published computations of the time of occurrence; they are usually observed by two, and sometimes by three persons, independently provided with instruments.

The great refractor continues to afford perfect satisfaction, and has enabled us to make some acceptable contributions to the general stock of astronomical knowledge.

Although, at the commencement of my last report, I expressed the pleasure which I then felt in the receipt and successful mounting of the transit-circle, I am now obliged to state that the divided circles of this instrument were found to have sustained some injury, such as to render the microscopic readings too discordant for the nicer purposes of ascertaining declinations; these discrepancies extend over an arc of sixty degrees. The instrument is in constant use as a simple transit, for which purpose we find it well adapted. The maker has offered to restore it without charge, excepting for such actual expenditure as he may be obliged to make for materials.

The five-foot equatorial has been in use for solar observation, and for the instruction of students in the theory and management of instruments of this class; it is also used for observation of occultations. The four-foot transit-instrument, made by Troughton and Simms, was sent to Washington in May last, to be fitted with double revolving tube-levels, and a diaphragm of forty-six wires, in order to make it correspond exactly to one which is mounted at the Coast Survey station near that city, for the purpose of co-operating in magnetic-telegraph communications of meridian transits of stars.

The remaining apparatus belonging to the Observatory is, I believe, in about the same condition as it was last year. A list of the instruments, and other property of the Observatory will be found appended to this Report.*

No very important changes have taken place in regard to the grounds and buildings.

---

* Omitted.

The trees and shrubbery appear to thrive, and promise, erelong, to enhance the beauty of the place and the comfort of the occupants, besides affording an excellent screen from dust, so annoying to the observer, and injurious to his instruments. An arrangement has been entered into, whereby Professor Gray has the temporary occupation of about an acre of the land belonging to the Observatory, to be used by him as a nursery for young trees and shrubs from the Botanic Garden.

The road on the southeastern side, running from Concord Avenue to Garden Street, having been graded, and a good sidewalk made, I have caused the main entrance from Concord Avenue to the Observatory grounds to be closed.

The observations of Neptune and Saturn have been continued, and the results communicated to the public. In the course of last winter we co-operated with Professors Walker, Loomis, and others of the United States Coast Survey, for the purpose of ascertaining, by means of the electric telegraph, the differences of meridians of certain stations of the United States Coast Survey, situated in Cambridge, New York, Philadelphia, and Washington; and it is proposed to resume these interesting experiments on the approach of winter, with the assistance of an electric clock, which I have devised and constructed for that purpose.

It is nearly two years since we commenced a close examination of the cluster of stars in Hercules, with the intention, if it was found practicable, of charting the stars contained in it from micrometrical measurements of angle of position and distance. This purpose has never been lost sight of, and whenever the state of the atmosphere permitted distinct vision of the individual stars, it has occupied a considerable portion of our time. At first, their multiplicity and condensed state seemed to defy all attempts at arrangement into groups, but by frequent trials we were enabled to recognize certain stars, and then, by commencing our triangulation at a principal star of a central trapezium, which is pretty conspicuous, and extending our measures to what may safely be considered as the boundary of the cluster, we have been enabled to form a map, which we think contains every star of this cluster that is distinctly visible with our twenty-three-foot refractor. We have divided the stars of this group into six magnitudes; those of the first and second magnitudes have been all measured in position and distance; the third magnitudes, partly in distance and position, and the rest by allignment from measured stars. This last method, where stars are so thickly strewn, is susceptible of a considerable degree of accuracy.

Our object in this undertaking is to establish a standard of comparison for the use of observers hereafter, to enable them to detect any changes which might take place, either in position or relative brightness.

The publications of the past year have been, —

1. Observations on Lassell's satellite of Neptune, and elements of its orbit, and the resulting mass of the primary.

2. On Encke's comet.

3. Hyperion (eighth satellite of Saturn) observations, and elements of its orbit.

4. Hind's new star, observations of 1847 and 1848, which afford no indications of parallax.

5. Micrometric measures of double stars.

6. Petersen's comet, observations and elements.

7. Moon-culminations of 1847 and 1848.

8. Notice of phenomena attending the disappearance of Saturn's ring, and the variable brightness of the satellites of Jupiter. A Paper read by George P. Bond, at the scientific meeting held at Cambridge.

9. Observations and elements of the Comet of 1849.

10. Description of the Observatory.

11. Memoir on some Applications of the Method of Quadratures. By G. P. Bond.

The Meteorological Journal has been continued as heretofore. The indications of the instruments are registered four times a day, and the temperature of the earth, from twenty to ninety feet below the surface, is ascertained monthly. A very considerable portion of my time since the last of March has been devoted to the carrying into effect a project for determining, by means of chronometers transmitted by the mail steamers, the difference of longitude of Greenwich and Cambridge Observatories.

Having been in correspondence for some time with Mr. Hartnup, the Director of the Liverpool Observatory, and finding him heartily disposed to aid in such an enterprise, I visited Washington in April last for the purpose of consulting with Professor Bache, the Superintendent of the United States Coast Survey, on this subject. I found him, as I had reason to expect, fully sensible of the utility of the undertaking, and disposed to incorporate it with the Coast Survey; and as it appeared to me consonant with my duties at Cambridge, I readily undertook to superintend the work. It was agreed to commence operations immediately, under the auspices of the Coast Survey, and Mr. R. F. Bond was despatched to England in the steamer of the 9th of May, to procure instruments and obtain information on certain points which could not so well or so readily be done by writing. My son returned on the 16th of August, and since then the chronometers have been traversing the Atlantic, remaining at the respective Observatories of Liverpool and Cambridge only a length of time sufficient for determining their local errors and rates of going.

The importance of availing ourselves of every method which may offer a rational prospect of success for determining with accuracy this arc of parallel will not admit of question. During several years past, I have been carrying on preliminary trials, and the close agreement of the results of different years afforded an assurance, that, by increased care in the determination of the local time at each extremity of the arc, and the judicious selection of chronometers, a degree of accuracy might be obtained of great value in an astronomical as well as in a nautical and geodetic point of view. That this is the view taken of this method by the most eminent astronomers of the age, we infer from the fact that Schumacher, Struve, and Airy have all at different times undertaken similar measures by the same means; the results have uniformly surpassed their previously formed estimates in regard to accuracy. Denmark, Russia, and England have fitted out expeditions of this kind at the public expense. In this way Professor Schumacher, of Altona, in 1821, connected the cities of Hamburg and Copenhagen. In 1824, Dr. Tiarks, assisted by Schumacher, determined with great nicety, after the same manner, the difference of meridians of Altona and Greenwich. It was, I think, in the same year that our countryman, R. T. Paine, commenced his series of chronometric determinations in longitude of some twenty-seven points in Massachusetts, which have since been incorporated in the State map, and satisfactorily tested by the triangulation of Mr. Borden. The Emperor of Russia, in 1833, ordered a survey of the shores of the Baltic by means of chronometers. But the most elaborate specimens of attention to minute detail in this kind of work may be found in the reports of Professors Struve and Airy; the former, on his measurement of the arc of parallel contained between the new Russian Central Observatory at Pulkova and Altona; and the latter, on extending the arc (Altona having been previously connected with Greenwich) westward to the island of Valentia, on the western coast of Ireland. It therefore has now become *our* duty to complete the chain which shall unite us more intimately with the Observatories of the Old World.

As the Astronomical Department of this Observatory is now firmly established by the bequest made in the will of the late Edward B. Phillips, for the support of observers, and the purchase of instruments and books, we are relieved from the painful anxiety, which could not heretofore be totally suppressed, notwithstanding the known liberality of Bostonians, that the Observatory might, after the first excitement of novelty had subsided, be left to struggle with adversity. Much has been done, and nobly done, towards the establishment of a complete Observatory; but it must be borne in mind that the Phillips Fund is strictly confined to three objects; namely, the support of observers, the purchase and repairs of instruments, and the purchase of books for a library.

It has for a long time been a subject of regret among those interested in meteorology and terrestrial magnetism, that there was not within the limits of the United

States a single regularly organized *Meteorological Observatory*, where a continued and systematic course of observation was pursued, such as might serve for a point of departure whence differences might be reckoned, and where instruments intended to be used on surveys and explorations might be verified by standards indicating the momentary condition of the atmosphere and magnetism of the earth. We are now in a condition to furnish all the instruments required for such an establishment, and need only a suitable building for their accommodation, such as would be afforded by the erection of the western wing of our Observatory, according to the original design.

Respectfully submitted,

W. C. BOND.

*Cambridge, November 7th,* 1849.

TO THE HON. JOSIAH QUINCY, HON. DAVID SEARS, HON. ABBOTT LAWRENCE, J. I. BOWDITCH, ESQ., ROBERT TREAT PAINE, ESQ., FRANCIS PEABODY, ESQ., HON. WILLIAM MITCHELL, *Committee for visiting the Observatory.*

---

## VIII.

## REPORT OF THE COMMITTEE APPOINTED BY THE OVERSEERS OF THE UNIVERSITY AT CAMBRIDGE TO EXAMINE THE OBSERVATORY, FOR THE ACADEMIC YEAR 1849-50, WITH THE ACCOMPANYING DOCUMENTS.

*Read and Accepted,* 15 *January,* 1851.

THE Committee appointed by the Board of Overseers of Harvard University, in March last, for the Observatory connected with that institution, respectfully report, that a meeting of that Committee was holden on the 4th of December last at the Observatory, and they carefully examined the great equatorial refracting telescope, and the other instruments and apparatus belonging to that institution, and found all in good order, except the transit-circle, which remains in the state in which it was the last year, for reasons specified in the annexed report of Mr. Bond, the Director of the Observatory. The attention of your Committee was particularly directed to a novel and most interesting invention for the purpose of "regulating the movement of a rotating cylinder, so that its motion may not only be steady and uniform, but that its revolutions may be performed with accuracy, in any given time desired." This invention consists in what has been termed an *Electro-Telegraphic Clock and Spring-Governor,* and its use consists in affording a means of communicating the moment of time of any phenomena observed at one Observatory to that of another, and *vice versa*, when connected together by telegraphic lines. The importance of a machine of this kind has been urged upon the attention of mechanicians by the Royal Astronomer of England, as an improvement greatly to be desired. Mr. Bond, the Director of the Observatory, with his two sons, George P. Bond, his Assistant, and Mr. Richard F. Bond, accordingly turned their thoughts to this object, and have invented this instrument, begun and completed within the walls of the Observatory, at the request and expense of the Superintendent of the United States Coast Survey.

The instrument has been approved by those more immediately interested in its success, and has had awarded to it, by the Massachusetts Mechanic Association, that society's gold medal. The adaptation of this instrument to the objects for which it was invented is stated in Mr. Bond's Report, both in respect of its general success and of its great accuracy. It is impossible for your Committee to express too strongly the impressions their examination of it made upon their minds, of the novel application of its principles, of the beauty and apparent perfection of its mechanical execution, and of its probable scientific results, when connected, as it now is, with the large equatorial and transit-circle.

The difficulties under which the Observatory labors, from the comparative inadequacy of its funds for the great objects of such an institution, and which have prevented this Observatory from pursuing the routine of duties prescribed and followed in the most perfect of the European establishments, are satisfactorily set forth in the annexed Report by the Director of the Observatory.

The path of usefulness which was within the pecuniary resources of the Observatory, and which was directed to the examination of nebulæ, of clusters of stars, to the measurement of double stars, to observations on comets, and a close inspection of planets, to which the superior power of the great refracting telescope and the requirements of astronomers in this country naturally pointed, was selected by the Director with great judgment, and pursued by him and his Assistant with spirit and skill. The detail of his and his Assistant's services in this respect cannot fail to be justly appreciated by the public, and to place this Observatory on a high stand for usefulness among the Observatories of the world.

Among the many evidences of talent and zeal indefatigably applied by the Director of the Observatory, and his principal Assistant, to the duties of their respective stations, your Committee have been particularly impressed by the following enumeration of *a part* of the result of their labors during the past year, viz.: the completion of the measurement of the distances and angles of position of the stars in the cluster of Hercules; the discovery of a remarkable variable star in Orion, of three new stars in the Trapezium, of an interior ring of Saturn, and of the comet of August, with the apparent reasonableness of the claim of the Director of the Observatory, in behalf of Mr. George P. Bond, his principal Assistant, for the first discovery of the comet of May, 1850, usually called Petersen's Comet. Without referring to other evidences of success in the observations made the past year, which the Report annexed enumerates, the Committee believe that few, if any, of the existing Observatories in the world can produce better or more illustrative proof of skilful, laborious efforts, during that period, in the cause of astronomical science.

Considering the known and justly appreciated talents of Mr. Bond and his principal Assistant, and their exemplary devotedness to the duties of their respective offices, the Committee cannot refrain from expressing their regret that the salary of the former has only been formally, and not efficiently raised; by adding indeed, nominally, three hundred and fifty dollars to his former salary, but at the same time exacting from him a like sum, under the form of rent for his dwelling in the Observatory, — a claim which had never before been advanced.

So also in respect of the salary of Mr. George P. Bond, the Director's principal assistant, your Committee deem it their duty to express an opinion, that, although his compensation has been advanced to one thousand dollars, it is yet far from being adequate to the talent he has displayed, and the constant exposure of his health in nocturnal observations at all seasons of the year. The Committee are of opinion, that, considering the nature of these services, and the great fidelity he has displayed in fulfilling them, he is entitled to an addition of at least five hundred dollars.

The Committee deem themselves the more justified in pressing this subject upon attention, from facts which have come to their knowledge, and which strongly impress their minds with the belief that the intimate friendship which subsisted between Edward Bromfield Phillips, and his classmate, George P. Bond, was among the motives which influenced his mind to lay the noble foundation, which he constituted by his last will, for the support of the offices which George P. Bond and his father then, as now, respectively held. Your Committee, therefore, cannot doubt, that by fixing a just and honorable salary to the office of the Director's principal Assistant, one of the views of that liberal benefactor will be most effectually sustained.

Your Committee perceive by the Report of the Director of the Observatory, with great satisfaction, that the liberality of private individuals has again come to the aid of the institution, by contributing funds to erect a new wing to its principal building, so as to complete it according to its original plan, thus adding greatly to its scientific usefulness, and giving to it accommodations for two transit-instruments, with space and conveniences well adapted to accurate magnetical operations, with other advantages set forth in the Report of the Director, which must result from this new evidence of the disposition of our citizens to patronize this important and interesting institution.

In closing this Report, your Committee cannot sufficiently express their gratification at the evidence the Report of the Director of the Observatory furnishes of the success of this institution, and of the apparent perfect adaptation of the great refractor to the objects for which it was obtained, its freedom from being affected by any sudden and violent atmospheric changes, and from injury by the accumulation of moisture on its object-glass; and that it so fully fulfils the hopes of those liberal and patriotic individuals, to whom the public are indebted for its attainment.

All which is respectfully submitted by

JOSIAH QUINCY,
WILLIAM MITCHELL,
ROBERT T. PAINE,
DAVID SEARS,
J. INGERSOLL BOWDITCH,
FRANCIS PEABODY,
*Committee.*

15*th January*, 1851.

---

## *Additional Report.*

THE Committee appointed on the Observatory at Cambridge, whose names are subscribed to the preceding Report, having, since the affixing their signatures thereto, had their attention drawn to the letter of President Sparks to William C. Bond, the Director of the Observatory, dated November 12th, 1850, which is hereto subjoined, and the subject of that letter being, in their opinion, of sufficient importance to be distinctly brought before the Board which have the superintendence of that seminary for their consideration, they respectfully submit the following remarks upon it, which they request may be regarded as additional to the preceding Report.

By that letter of President Sparks to Mr. Bond, it has been, for the first time, brought to the knowledge of your Committee, that, by the statutes relative to that institution which were passed in December, 1849, *the Observatory at Cambridge* received the name of "the Observatory of Harvard College," and that on this subject the President adds, "that, as this institution is a part *of the University*, and as the College has contributed so largely from the general fund for its establishment, it is deemed important that the connection should be shown, by the use of the name on all proper occasions."

And Mr. Bond is accordingly requested, in all communications of an official character, whether intended for publication or not, to make use of the name prescribed by the statutes.

On these views of the Corporation, thus expressed by the President, your Committee respectfully remark, that, so far as this name is justified by the language of the statutes, it is yet, they apprehend, *a subject for reconsideration*, which they respectfully suggest; as, in their judgment, what name shall be given to it, or whether it shall remain, as heretofore, without any designation except that derived from its locality, are questions very far from being indifferent or unimportant to the future prospects of the institution. So long as it remains without other name than that derived from its locality, it will be open to receive that of some wealthy individual, who may have the natural and honorable ambition of connecting this noble institution with his own name, by a donation far exceeding any and all it has hitherto received. Such a donation, your Committee, far from thinking improbable, regard as very likely, if the Observatory be left open, in respect of name, to avail of those beneficial contingencies, which, in the course of time, may reasonably be anticipated from the natural instincts of the human heart, when they happen to be united with great wealth, destitute of children and near kindred.

Nor can the sum advanced by the College in aid of the Observatory be regarded as a "contribution to its funds," since the Observatory is made a debtor to the full amount, with an intention of reimbursement, and this claim efficiently maintained by charging the Director of the Observatory with rent for his dwelling in the house belonging to it.

Should it, however, be deemed inexpedient that the Observatory should be separated from the venerated name of Harvard, then your Committee respectfully request that it may be permitted to take the name which was authorized by the Constitution of the Commonwealth in the year 1780, which was adopted by the distinguished men who were at that time both members of the Convention which formed that Constitution, and also members of the Corporation of the seminary, and by which, under their auspices, it took, and made use of, in all official papers and publications, with the exception only of legal instruments, for upwards of sixty-four years, and which it retained until within about four years past, when it was changed, for no other purpose, as far as is publicly known, than the desire to make the general name of the institution coincide with the legal name of the Corporation which has the charge of the superintendence of the institution, and of its funds.

To an Observatory which has, from the nature of its objects and duties, a necessity of frequent intercourse with foreign seminaries, it is far from being unimportant that *the most comprehensive name, and that by which it is best known in Europe,* should be retained. Your Committee therefore respectfully suggest, if it shall not be deemed advisable that the Observatory should be hereafter, as it has been heretofore, designated by the name of the city in which it is located, that it may be permitted to take the name of *The Observatory of Harvard University.*

All which is respectfully submitted, by

JOSIAH QUINCY,
ROBERT T. PAINE,
DAVID SEARS,
J. INGERSOLL BOWDITCH,
FRANCIS PEABODY,
*Committee.*

6*th February*, 1851.

## *Report of the Director to the Visiting Committee of the Observatory of Harvard University.*

### 1850.

IN again meeting the Committee on the Observatory, the Director has great pleasure in reporting the evidence of continued confidence which has been exhibited by its friends during the last year, in contributing the requisite funds for the completion of the buildings of the Observatory according to the original plan, with such improvements as the advance of science and the experience of past years may have suggested.

The condition of practical astronomy and meteorology in the United States at the time of the first establishment of this Observatory, rendered it evidently inexpedient to adopt, or copy very strictly, the routine of duties pursued at any, even the most excellent, of the European establishments. At Greenwich, the *places* of the sun, moon, planets, and certain fixed stars called standard stars, were constantly observed with every refinement of exactness which the skill and diligence of a numerous body of selected observers, aided by the best instruments that could be obtained in England, could accomplish.

At the Russian Imperial Observatory, furnished with the most complete apparatus that the world has ever yet seen, and a staff of observers and assistants amounting altogether to two hundred persons, and possessing, through the patronage of the Emperor, almost unlimited pecuniary resources, the astronomers were devoting themselves more especially to stellar astronomy, and to the nicer determination of the *parallaxes* and *proper motions* of the fixed stars generally.

In many of the European Observatories, an almost uninterrupted search is kept up for smaller planets, and comets; others again devote their energies and means to the measurement of the position and distances of double stars, and to the forming of maps of the lesser stars in certain zones of the heavens.

At our own National Observatory, it is purposed to form a "Washington Catalogue" of the place and character of every star visible in their telescope, which probably will include stars of the twelfth magnitude, numbering perhaps hundreds of thousands.

We have no occasion, however, to apprehend that the astronomical field will be fully occupied in our day. The difficulty in organizing a new Observatory does not arise in a lack of objects worthy of investigation, but in the choice of such as can be most fully and economically developed by the means at the disposal of the astronomer.

An appropriate path of usefulness was indicated to us by the superior powers of our great refracting telescope, and by the requirements of astronomers in this country. We considered that the purposes for which the Observatory was established would be best fulfilled by a careful examination of nebulæ and clusters of stars; the measurement of double stars; the close inspection of the planets; observations of comets and planets, when in positions inaccessible to ordinary instruments; and of occultations of stars by the moon. These have accordingly been the principal purposes to which we have applied the powers of our large refractor. The smaller telescopes are used for obtaining duplicate observations of eclipses and occultations, and examination of the sun.

With the meridian instruments we obtain, at every favorable opportunity, transits of stars for the correction of our astronomical clocks. This time is, by a specific arrangement, disseminated to the principal railroad stations in the Commonwealth. Moon-culminations are likewise observed with these instruments. These observations are useful, not only for the correction of the assumed differences of longitude between our own and other fixed Observatories, but as co-operating with astronomical observers appointed on surveys by the general government, in distant parts of the country, of whom there are a greater or less number constantly engaged, either in running boundary lines, or settling the positions of points on our own coast.

To these duties we add those required in keeping a regular meteorological journal, and occasional observations of terrestrial magnetism, and participation in any useful kindred work that may seem to require our co-operation.

In reporting on the condition of the grounds and buildings of the Observatory, the Director would earnestly recommend continued attention to the cultivation of shrubbery and trees on the eastern, southern, and western declivities; experience thus far having shown, that such a protection from dust has been of essential importance to the preservation of the instruments, while at the same time it secures the comfort and quiet of the observers. It is estimated that the buildings will require this year an expenditure of about three hundred dollars for repairs; but this, it is understood, will be provided for in the estimates of the Treasurer of Harvard University.

The additions now making to the Observatory buildings will comprise a meridian-transit room, affording sufficient accommodation for two instruments; and a basement room, forty by twenty-four feet, specially constructed for magnetical operations, particular care having been taken to exclude all such materials as would be likely to influence the indications of the magnets.

It is proposed to devote one apartment of this building to the reception of the books of the "Phillips Library"; the northern rooms to be occupied for computing and meteorological purposes. It is intended that all the meteorological and magnetical instruments shall be so constructed as to register their indications, either photographically or mechanically, on a cylinder or cylinders, carried by a powerful spring-governor, and thereby obviate the tedious, constant watching of observers. The apparatus will require necessarily a considerable space: this, however, has been amply provided for. The third story will be appropriated to apartments for the storage of unbound books, pamphlets, and instruments and materials not in daily use, and for a work-room.

The whole is to be surmounted by a dome of twelve feet in diameter, in which it is proposed to mount the five-foot equatorial and the comet-searcher.

The instruments are in as good condition as they were at the Committee's last visit. It is gratifying to find that the great refractor remains still in as perfect condition as when it was first mounted, and it does not appear to have suffered in the slightest degree from the sudden and violent atmospheric changes to which it has been exposed in our variable climate; and more particularly, that no permanently injurious effects have resulted from the deposit of moisture, which at some seasons takes place over its whole surface. By sufficient attention in keeping the instrument oiled, and the object-glass wrapped in woollen cloth, there seems to be no occasion to apprehend any injury from this source.

The smaller equatorial has occasionally been used for Daguerreotype experiments; and it will answer a most valuable purpose when placed, as it is intended, in the dome of the new building, where, in connection with the comet-searcher, and the requisite apparatus for photographic operations, it can be used more efficiently than in its present situation.

The portable telescopes, meteorological instruments, magnetic apparatus, clocks, chronometers, &c. are in about the same condition as last year. We shall need an additional astronomical clock and sidereal chronometer.

The transit-circle has been in constant use as a transit-instrument, and there is no probability that it can be spared for examination until another instrument is procured and mounted, to be used in its stead.

The Phillips Library has not received any accession from the fund destined for its support. The only additions to the library have been by donations from scientific societies and individuals. Among the donations to the Observatory there has been received, from the executors of the late Captain Josiah Sturgis, a sextant which he had in his will directed to be given to the Observatory.

In regard to the personal establishment of the Observatory, we have had, since the middle of July, the additional assistance of Mr. Charles W. Tuttle. This young man appears to be strongly interested in our pursuits, steady and industrious. He is yet on probation, with the consent of the Corporation of Harvard College. The salary of the first Assistant has been increased to one thousand dollars, from the Phillips Fund. The Director's salary has also been advanced by an addition of three hundred and fifty dollars, from the Phillips Fund, and he is now charged the same additional amount as rent for the dwelling-house.

In February last I was requested by the President to prepare for publication the Reports on the Observatory, and a selection from the documents accompanying them. But on inquiry of the Treasurer, I ascertained that there would not be any available funds to meet the expense of such a publication. I regret this the less, because there are at present so many periodicals of large circulation and easy access, through which we can readily communicate with the public.

The arrangements and calculations of the chronometric work of 1849, for an independent determination of the difference of longitude between Greenwich and Cambridge Observatories, have occupied a large portion of our time. A complete copy of the work has been sent to the Superintendent of the United States Coast Survey, as a large proportion of the funds required to carry it on had been advanced by him. The very able and unwearied assistance which we have so liberally received in the prosecution of this undertaking from John Hartnup, Esq., the Director of the Observatory at Liverpool, England, merits and receives our warmest acknowledgments.

We have accumulated a great many unreduced observations of Mars, taken near the opposition. They are intended to be used as data for determining the parallax of the sun, from the diurnal parallax of the planet observed east and west of the meridian, and also for comparison with the observations made on the western coast of South America, by Lieutenant Gilliss, under orders of the United States government.

The measurement of the distances and angles of position of the stars in the cluster in Hercules for the present year has been completed. It is expected that it will require the observations of many years to decide satisfactorily the question of relative change of position of the stars composing this group.

The discovery of a remarkable variable star in Orion, of three new stars in the Trapezium, of an interior ring of Saturn, and the comet of August, and I believe I should, in justice to my first Assistant, Mr. G. P. Bond, add the comet of May, 1850, usually called Petersen's Comet, as it was seen by Mr. George P. Bond two days earlier than it was in Europe, — these are the principal disclosures of this Observatory since my last report. With the assistance of Mr. Whipple, daguerreotypist, we have obtained several impressions of the star Vega ($\alpha$ Lyræ). We have reason to believe this to be the first successful experiment of the kind ever made, either in this country or abroad. From the facility with which these were executed, with the aid of our great equatorial, we were encouraged to hope that the way is opening for further progress. If it should prove successful when applied to stars of less brilliancy than $\alpha$ Lyræ, so as to give us correct pictures of double and multiple stars, the advantages would be incalculable.

There are now prepared for the press one hundred and thirty occultations observed at this place. These are in addition to the list already published.

To the London Astronomical Society's Notices we have contributed the following: —

Past Perihelion Observations at the Reappearance of Schweitzer's Comet.

Paper on the Disappearance of Saturn's Rings.

Variableness of Jupiter's Satellites.

Observations and Elements of the two Comets of 1850.

And to Dr. Gould's Astronomical Journal: —

Discussion of all the Observations of the Great Southern Comet of 1844-45. By G. P. Bond.

A Method of Computing the Distance of a Comet from the Earth. By G. P. Bond.

Notices and Elements of the Comets of 1850, and an Ephemeris of the Second Comet of 1850.

To these might be added sundry communications on subjects connected with the Observatory, made to the Boston daily papers.

The work which has chiefly engrossed our attention, however, is the application of electro-telegraphic communication to the purposes of astronomical observation.

In the summer of 1848 we were engaged, with the officers of the United States Coast Survey, in ascertaining differences of longitude by means of the magnetic telegraph. The method then pursued was to regulate the chronometer or clock by transits of stars over the meridian of the place, and communicate the time to the distant station by "tapping" on the break-circuit key of the telegraph armature-magnet as nearly as we could in coincidence with the beats of the chronometer, while at the same time the "taps" were recorded on a "Morse's fillet" of paper by the recording magnets at each of the stations with which we were in magnetic communication.

One evening while thus employed, Professor Sears C. Walker proposed to me that we should communicate the transits of the star by telegraph directly from observation, while the register kept its tally, and another person noted the time by the chronometer. This may well be considered (at least as far as I have been informed) as the first direct connection of the magnetic telegraph with astronomical observing. This suggestion was immediately put in practice; but as the details proved inconvenient, and as it was yet evidently susceptible of being rendered valuable, it was reserved for further consideration.

I then proposed to Professor Walker, and subsequently (in September of that year) to the Superintendent of the Coast Survey, to insulate the escapement of an astronomical clock, and connect the telegraph wires with the insulated parts, so that the pallets of the clock, in their usual alternations, would break and restore the galvanic circuit. At the instance and expense of the Superintendent of the United States Coast Survey, I caused such a clock to be made, and it is found to answer perfectly the intended purpose. But another and far more serious difficulty presented itself in the *accurate registry* of the beats of the clock after being transmitted by the galvanic circuit; and it was at this point that further progress in the application of this method to astronomical observing was arrested.

The machine which we have invented and made for this purpose, at the request and expense of the United States Coast Survey, and of which the Committee has witnessed the operation, we call a Spring-Governor. It has met the approbation, not only of those who were immediately interested in its success, but of the Committee on New Inventions appointed by the Massachusetts Mechanic Association, who have awarded for it the Society's gold medal.

Respectfully submitted,

W. C. Bond.

*Harvard College Observatory, Cambridge, December* 4, 1850.

To the Hon. Josiah Quincy, Hon. Abbott Lawrence, Hon. David Sears, Hon. William Mitchell, J. I. Bowditch, Esq., R. T. Paine, Esq., Francis Peabody, Esq., Hon. Levi Lincoln, *Committee for visiting the Observatory.*

## IX.

## REPORT OF THE COMMITTEE APPOINTED BY THE BOARD OF OVERSEERS OF HARVARD UNIVERSITY FOR VISITING THE OBSERVATORY, FOR THE YEAR 1850–51, WITH THE ACCOMPANYING DOCUMENTS.

*Read and Accepted*, 30 *January*, 1852.

THE Committee appointed for visiting the Observatory at Cambridge respectfully report, that on the 4th of December, 1851, they attended that service, and carefully examined the institution, inspected the great telescope, and the other instruments appertaining to the Observatory. They found all in perfect order, with the exception of the transit-circle, which remains in the state in which it appeared at its first importation; the injury it received on its passage to this country not having been yet repaired. In other respects the institution and its apparatus are in that highly creditable state of neatness and order which characterizes the Director and his Assistant.

At this meeting of your Committee, the Director of the Observatory presented his annual report of its state and his proceedings, on which your Committee forbear to comment, as it is subjoined and made a part of this report; and will, of itself, testify to the fidelity of the Director and his Assistant, in the fulfilment of their laborious duties.

Concerning the several suggestions made by the Director in his report, your Committee are of opinion, that his intimation relative to effecting insurance against fire is worthy of attention. In their judgment, insurance should be made of the great telescope and other instruments, of the library, and the buildings constituting the Observatory, if none has yet been effected.

Your Committee also entirely concur in opinion with the Director, that the occupation of the grounds connected with the Observatory as a nursery for trees for the accommodation of the Botanic Garden, ought not to be continued longer than is absolutely necessary to give time for the trees to arrive at a state fit for transplanting; and the grounds surrounding the Observatory should be free from all occupation, except such as has reference to the objects of that institution.

They unite also with the Director in recommending that the present entrance to the Observatory from Concord Avenue should be permanently closed, so as to prevent its being used hereafter for the purposes of general travel, and that a new avenue should be opened in such a position and direction as to adapt it exclusively to the use of the

Observatory. The Committee are also of opinion, that the grounds west of the cross street leading from Garden Street to Concord Avenue should never be separated from the institution, or applied to any purpose not connected with its use.

Your Committee cannot refrain from expressing their great satisfaction at the statement of the Director concerning the continued efficiency of the great telescope, and particularly the undiminished power of its object-glass, its freedom from decay or efflorescence, evidences of successful result which cannot fail to be subjects of congratulation to those liberal donors who contributed so largely to its attainment.

George P. Bond, the efficient Assistant of the Director of the Observatory, having during the last year visited the principal Observatories in England, Ireland, France, Germany, and Russia, and having been received with marked attention by scientific men in each country, as well on account of his reputation as a successful observer as on that of his connection with the Observatory at Cambridge, your Committee had hoped to have been enabled, from his own report, to have presented to the Board of Overseers a full statement of the course of his proceedings while in Europe, and their results. They have to regret their disappointment in that hope, by an illness which seized Mr. Bond almost immediately after his return to this country, which has confined him more than six weeks to his chamber, threatening seriously his life, and from which he is as yet only slowly recovering.

Under these circumstances, the Chairman of this Committee, at their request, addressed, on the 5th of December last, a letter to the Director of the Observatory, inquiring under what auspices his son and Assistant had made his visit to Europe, from what funds its expense had been defrayed, the objects proposed and attained by it, the Observatories he had visited, the facilities in promotion of his views which he had received from the Directors of other Observatories and from men of science in Europe, and such other information illustrative of his purposes and their results, as, during the illness of his Assistant, he has been able to obtain from him.

In reply to these inquiries, the Director addressed a letter to the Chairman, which is subjoined to this Report. It is impossible for your Committee, after reading this letter, to refrain from expressing their sense of the gratifying evidence it affords of the interest taken by the Directors of European Observatories, and in general by men of science in every country Mr. Bond visited, in the objects of his tour; who, by responding readily to his inquiries, and by granting free use of their instruments, yielded every facility adapted to give success and usefulness to his pursuits.

By order of the Committee,

JOSIAH QUINCY, *Chairman.*

30*th January*, 1852.

## *Report of the Director to the Visiting Committee of the Observatory of Harvard University.*

### 1851.

Gentlemen: — At the last annual meeting of the Board of Visitors, I had the pleasure to announce the contribution, by friends of the Observatory, of a sum nearly sufficient to defray the expense of completing a western wing to the Observatory, according to the original design. This object, I have now the satisfaction to state, has been fully accomplished: the building is finished, and, with the exception of its being at present destitute of furniture and warming apparatus, is ready for occupation.

The improvement which this additional building has produced in the appearance of the Observatory, as seen from a distance, and which is acknowledged by those who have noticed it at all, is of less importance than the convenience which its internal arrangement affords for the disposition of our constantly accumulating mass of books and papers, and the proper accommodation of many of our instruments. This is, and will continue to be, a source of great satisfaction to all who are, or may hereafter become, connected with the business of the Observatory. The bills having been paid from the subscription fund, Mr. Bowditch has transferred the interest, in trust, to the Corporation of Harvard College.

During the past summer, all the former buildings have been put in good repair; particular attention has been paid to security from fire, — an object not easily attained, where a considerable portion must of necessity be constructed of wooden materials. It has been endeavored to render the central part fire-proof, in order that it may, in the event of either wing taking fire, form a barrier to the further progress of the flames. This, it is thought, has been accomplished, by removing the most exposed part of the wooden coving below the dome, and substituting for it a complete casing of sheet copper, and putting double iron doors and window-shutters to both the east and west entrances, and iron platforms to the balconies. It is, however, submitted to you, gentlemen, to judge, after personal examination, whether prudence demands the additional security of insurance, or any further safeguard.

In regard to the grounds about the Observatory, a portion still continues to be occupied as a nursery for trees belonging to the Botanic Garden. How long it will be needed for this purpose, I have no means of ascertaining; but I am decidedly of the opinion, that the occupation of the ground for this purpose should not be continued beyond the time requisite to bring forward the trees now upon the ground to a state fit for transplanting.

We continue to be somewhat annoyed in consequence of a mistake which a portion of the public fall into by supposing that the road in front of the Observatory is a public highway; they not being aware how much the successful prosecution of our labors depends on quiet. At some future time, it may be deemed expedient to close the entrances on Garden Street and Concord Avenue, and to open one opposite Mr. Dixwell's house, southeast of the Observatory.

The principal instruments are, I believe, in as good condition as they were last year, with very small allowance for decay. The large telescope does not appear to suffer any diminution of its powers, particularly in regard to its object-glass. I have recently had occasion to separate the lenses composing the object-glass, and embraced the occasion to examine their condition critically, and satisfied myself that there was no indication of decay or efflorescence; and also, in taking apart the micrometer of this instrument to renew the spider-lines, I found all in good order.

The transit-circle has been so constantly required in use as a transit-instrument, that we have been unable to spare it for examination of its circles; it therefore remains, as last year, an excellent transit.

There have been added to the apparatus a fine Fox dip-circle, a sextant, and several instruments of minor importance. These have all been charged to the Phillips Fund. The old Adams equatorial, the five-foot Dolland spy-glass, the Ellicott clock, and some other things, have been transferred to Professor Lovering's department, and a theodolite to Professor Eustis. These, I presume, are to be credited to the Observatory account.

A pier has been built in the west transit-room, and the Troughton and Simms transit mounted thereon. This instrument has been furnished with new diaphragms of twenty-five wires, and a diagonal eye-piece of the recent invention of Mr. Wurdimann of Washington. These improvements add considerably to the powers of the instrument, and are particularly adapted to the electric method of observing for difference of longitude. The main wires of the Vermont and Boston Telegraph are now carried into both the east and west transit-rooms, with a branch to the dome and a connection with a local circuit for our own battery, so that, at a few minutes' notice, we can connect with distant stations in all directions, as we have at Boston a connection with Morse's line. For a great part of the expense of this arrangement we are indebted to our intercourse with the operations of the Coast Survey, which is literally embracing all those who are able and willing to work for the Commonwealth.

The first Assistant, while in Europe, availed himself of the opportunity of the late Professor Jacobi's library being on sale, to purchase it entire. It was paid for from the Haven Fund of the College, with the expectation that a certain portion of the books should be transferred to the library of the Observatory, on payment of the cost, from the Phillips Fund.

The observations for the past year embrace the usual routine of meridian transits of stars, moon-culminations, occultations of stars by the moon, a solar eclipse, measurements of double stars, examinations of nebulæ, the comets of Brorsen and D'Arrest, eclipses of Jupiter's satellites, measures of the rings of Saturn, places of some of the smaller planets, and the ordinary meteorological record, and occasional attention magnetic perturbations.

In regard to the recording of observations, we have devoted a considerable portion of our time to the improving and establishing of the electric method; being convinced, from more than a year's experience, of its superior accuracy, despatch, and convenience, and that it will be permanently adopted in astronomical observation.

As the general government are every year sending out parties for explorations and surveys of boundaries and territories, we are called upon to make corresponding observations of the moon, for the purpose of settling differences of longitude. Our observations of this kind are regularly communicated to the Coast Survey, and occasionally to individual surveyors in the employment of government.

The discovery at this Observatory of a new inner ring of Saturn has been fruitful in interesting speculations. After collecting all the information within our reach in regard to the appearances of the rings at different periods, and comparing these with our own observations, Mr. G. P. Bond has been led to an analytical investigation of the constitution of the rings. His paper on this subject, after having been read before the American Academy on the 15th of April last, was published in its Memoirs, and also in the Cambridge Astronomical Journal, and subsequently was brought before the American Association for the Advancement of Science, by Professor Peirce, at their May meeting in Cincinnati. In this paper Mr. Bond does not rest his argument solely on observation, although he maintains that any hypothesis should harmonize with it, but proceeds to an analytical development of the constitution of the rings, and arrives at the conclusion that they are in a fluid state, or composed of particles of matter susceptible of independent change of place.

During the past summer, I have been engaged in conducting a second expedition for the nearer determination of the difference of longitude between the Royal Observatory at Greenwich and this place. This work was undertaken at the request of the Superintendent of the United States Coast Survey, and is in connection with a similar work carried on by me in 1849, for the Coast Survey. This season we have had thirty-seven chronometers passing to and fro in the British and North American steamers, between the Observatories of Liverpool and Cambridge. In this connection, I may mention an instance of the great rapidity of communication at the present day. Mr. Homans, in whose charge I placed the chronometers during two successive voyages, went from Cambridge to Liverpool, remained while the Director of the Observatory there obtained the requisite observations, and returned to Cambridge, on each occasion, within the month.

I am at present engaged in superintending electric telegraph operations, for the purpose of ascertaining the difference of longitude between this place and Halifax, Nova Scotia. Some years since, the question arose, on the adoption of a zero of longitude to be used in settling points on the Northeastern Boundary, whether Quebec or Cambridge should be taken as the initial point best determined relatively to Greenwich; the American surveyors having adopted Cambridge, and the British surveyors, Quebec.

The investigation which followed led the Astronomer Royal and Admiral Beaufort, chief of the Hydrographical Bureau, to decide in favor of Cambridge. Since then the British surveys of the Bay of Fundy and Gulf of St. Lawrence, respectively conducted by Commander Shortland and Captain Bayfield, have been progressing, and have reached a point where it is important that they should adopt a zero for the longitude of their maps and charts. Both these gentlemen have written to me, desiring to connect their surveys with our Observatory, the longitude of which is considered as better known in relation to Greenwich than any other point on this continent.

On mentioning the subject to Professor Bache, he immediately saw its utility, and the important bearing which it had on the interests of the United States, and offered the use of suitable instruments to be placed at Halifax, and also approved estimates for the expenditure, so far as the United States were interested.

As it was thought possible that the whole distance to Halifax (seven hundred and seventy miles) might not be reached with one battery, a station has been established at Bangor on the Penobscot, under charge of Professor S. C. Walker, assisted by Count Pourtales. Mr. R. F. Bond has proceeded to Halifax, where he is sojourning with Captain Shortland; the transit-instrument which he carried with him being established at a small temporary Observatory erected in the dock-yard.

We have had several nights' communication with Bangor, and Bangor has reached Halifax, but as yet the circuit has not been distinctly carried through from Cambridge to Halifax.

But I must again refer to the work which has engaged most of our time and attention; namely, the perfecting, and bringing into use and notice, of the American method of recording astronomical observations by the aid of the electric current.

In my report of last year, I mentioned that we had constructed an apparatus, consisting of an electric clock and spring-governor, for the United States Coast Survey, on a plan submitted to Dr. Bache and approved by him. This apparatus, having been fully tested here, was, with the approval of Dr. Bache, taken to England. Mr. Richard F. Bond, being under the necessity of visiting and making some stay in England, for purposes connected with the chronometer expedition, took charge of the apparatus. Mr. George P. Bond accompanied him on the voyage, intending to visit the principal Observatories in Europe, and to become acquainted with their conductors and their modes of observing, and in general to obtain all such information in regard to the present state of astronomy as might come within his reach.

On their arrival in London, they were invited to put their electric apparatus in operation at the rooms of the Royal Astronomical Society, at Somerset House, where it engaged the attention and elicited the approbation of those astronomers who were assembled at the meeting of the Society.

At the request of several distinguished scientific gentlemen, the apparatus was transferred to Ipswich, the place of meeting of the British Association for the Advancement of Science. Here it was again put in motion, and tested in various ways, and finally it was strongly urged to place it in the department assigned to American inventions at the great exhibition in Hyde Park. We have since been informed, that one of the five Council Medals appropriated to American inventions has been awarded to us. It is a gratifying circumstance that this invention is known and spoken of in England only as the "American method," and that the Astronomer Royal has laid the wires at Greenwich preparatory to introducing it there.

We have during the past year constructed another sidereal electric clock and spring-governor, the same which you now see in use for the Observatory.

Not the least interesting part of our employment has been the assisting of Mr. J. A. Whipple in taking daguerreotypes of the moon and several of the stars. With the moon he has been particularly successful, and the improvement on last year's impressions is very decided. Some of those, taken by the aid of our great object-glass, excited the admiration of eminent men in Europe, to whom Mr. G. P. Bond gave specimens. For these Mr. Whipple has been awarded a prize medal at the great exhibition in Hyde Park.

Respectfully submitted,

W. C. BOND.

*Cambridge, December* 4, 1851.

TO THE HON. JOSIAH QUINCY, HON. DAVID SEARS, HON. WILLIAM MITCHELL, J. I. BOWDITCH, ESQ., ROBERT TREAT PAINE, ESQ., FRANCIS PEABODY, ESQ., *Committee for visiting the Observatory.*

## *Letter from Mr. W. C. Bond to the Hon. Josiah Quincy, Chairman of the Committee for Visiting the Observatory of Harvard College.*

Cambridge, December 31, 1851.

DEAR SIR: — Yours of the 5th instant was duly received, but in consequence of serious illness I have been unable to answer the inquiries of the Committee at an earlier date. Even now I am under the necessity of being very brief, and can only touch upon the principal points connected with Mr. G. P. Bond's visit to Europe.

In March, 1851, the President of the University granted my first Assistant leave of absence for six months; and subsequently to his departure the Corporation of Harvard College voted to continue his salary during his absence. He sailed for Liverpool in the steam-packet of the 9th of April, 1851.

Mr. Bond arrived in England on the 21st of April, and was invited by the Director to take up his abode at the Liverpool Observatory. This afforded him an excellent opportunity for observation, and for becoming acquainted with the methods of observing adopted by Mr. Hartnup and Mr. Lassell, both eminent in their respective departments.

In London, Mr. Bond lectured before the Royal Astronomical Society on the subject of the American method of recording astronomical observations. His remarks were illustrated by the exhibition of the same apparatus which had been in use at our Observatory, it having been taken to England for that purpose. He was very kindly received, and his remarks published.

His intercourse with Mr. Airy, the Astronomer Royal, Sir John Herschel, Lord Rosse, Sir David Brewster, &c., was of the most friendly description, and fruitful of information on the subjects of his visit.

While in London, Mr. Bond fortunately obtained early information that the valuable mathematical library of the late Professor Jacobi was on sale; this he purchased on account of Harvard College, to be divided between the College Library and the Phillips Library of the Observatory.

In the month of May he visited Paris, was received in a friendly manner by Le Verrier, Faye, Villarceau, Biot, Foucault, &c., visited the Observatory, attended a meeting of the French Academy, and presented there a daguerreotype of the moon, taken with our large telescope. Returning to London, he attended the meeting of the British Association for the Advancement of Science.

The *spring-governor* and *electric clock* had been, by special request, removed to Ipswich, the place of meeting of the British Association this year. Here the apparatus was again put in operation, and its adaptation to the purposes of astronomy explained. Subsequently, at the strong recommendation of Colonel Reid, Chairman of the Executive Committee of the Great Exhibition, and of Sir David Brewster, it was removed to Hyde Park, and put up in the department assigned to American inventions, and at the close of the exhibition one of the Council Medals was awarded to it.

Mr. Bond then took the steamer for Hamburg, where he was most hospitably received by Professor Rumker, the Director of the Observatory, and by Dr. Petersen of Altona. Here he remained during his stay in Hamburg. Thence he proceeded to Travemunde, a port on the Baltic, and then took passage in a steamer for Copenhagen and Gottenburg, and ascended the river Gotha in Sweden, as far as a place called Lilla-Edet. The purpose of this journey was to witness the total eclipse of the sun, on the 28th of July. In this he was entirely successful, and highly gratified. Returning to Travemunde, he went on board the steam-packet bound for Cronstadt in Russia. On his arrival at this place, he was agreeably surprised at meeting an officer who had instructions to conduct him to the Imperial Observatory at Pulkova, where Mr. Bond resided during his stay in Russia, by invitation of the Director, Professor Struve, making occasional excursions to St. Petersburg and elsewhere.

While at this Observatory, Mr. Bond had every facility afforded him by the Director for becoming acquainted with the construction and use of the noble instruments belonging to it, not only by oral instruction, but by being allowed to operate with the instruments. This was a great privilege, as thereby he became the more fully instructed in the manipulations and methods of observing. Indeed, it was impossible that any persons could have been more kind, liberal, and attentive than Professor Struve and his family were, to one who came among them, as a stranger almost from another world, to seek information at the fountain-head of stellar astronomy.

On returning from Russia, he took the route of Stettin, Berlin, Dresden, Leipsic, Halle, Gotha, Göttingen, and Geneva, meeting with friendly receptions from Baron Humboldt, Encke, Dr. D'Arrest, Rosenberger, &c. At Leipsic he obtained information from Dr. Flügel, and several booksellers, relative to the purchase and transportation of books. At Bonn he met Professor Argelander; at Göttingen he visited the venerable Gauss; at Gotha, Hansen; at Geneva, Professor Plantamour, &c.

From Geneva he went to Chamouni, in the expectation of being enabled to obtain, by aid of the abrupt and lofty peaks of the Alps, some explanation of the phenomena which attended the total eclipse of the sun, as observed by him in Sweden. In this, however, he was disappointed, as the weather proved stormy during his stay among the mountains.

Descending the Rhine, he arrived in England on the 3d of October, and passed several days with Messrs. Challis, Johnson, and Adams, at the Observatories of Oxford and Cambridge. He visited, by invitation, Lord Rosse, at Parsonstown in Ireland, and was so fortunate as to have two favorable nights for observation with the giant reflecting telescope. There he also witnessed the process of polishing the great mirror by the aid of a steam-engine. He returned to Liverpool in season to pass two nights with Mr. Lassell, at the Starfield Observatory, previous to embarking for home. After a rather boisterous passage, he arrived at Cambridge on the 15th of November, and was immediately taken ill of typhoid fever, which has confined him to his bed six weeks. He is now, we hope, fairly on the recovery, and will embrace the first convenient opportunity to report more in detail than I am at present able to do, all the events of his voyage as connected with the interests of the Observatory.

I remain, very respectfully, Sir, yours truly,

W. C. Bond.

---

## X.

### Report of the Committee appointed by the Board of Overseers of Harvard University for Visiting the Observatory, for the Academic Year 1851–52, with Accompanying Documents.

*Read and Accepted,* 21 *January,* 1853.

The Committee appointed for visiting the Observatory of Harvard College submit the following Report.

The Committee assembled at Cambridge on the 17th of November, 1852, to attend to the service assigned to them; present, Mr. Winthrop, Mr. Quincy, Mr. Bowditch, Mr. Paine, and Mr. Borden.

The Committee spent two or three hours at the institution, carefully examining into its condition, and receiving the reports of the Director and his Assistant. They are gratified at being able to report, that they found everything in the most satisfactory state. The grounds have been improved. A new wing to the building, undertaken at private expense, has been completed.

The Phillips Library has been enlarged, and contains nearly nine hundred volumes, mostly of a scientific character. The instruments, with the exception of the transit-circle, which remains as it was found on its first importation, are in perfect order. The great equatorial telescope continues to justify every expectation; the power of its object-glass is in no degree impaired; and its results are as satisfactory as in former years.

Meantime the field of its usefulness has been extended by the ingenuity of the Assistant Observer, Mr. G. P. Bond, who has contrived a mode of applying it to purposes which were hitherto confined, in a great degree, to meridian instruments.

The peculiar character and striking results of this improvement are set forth at length in the annexed report of the Director, which contains also a full account of the operations of the Institution during the past year, and which exhibits a gratifying picture of its progress and success.

Accompanying the report of the Director, there will also be found two valuable and instructive papers. One of them is an exact historical account of the course of invention and improvement in the art of determining longitudes by the electric telegraph, prepared by Sears C. Walker, Esq., and communicated to our Observatory by Professor Bache, of the United States Coast Survey.* The other is the report of the Assistant Observer, Mr. G. P. Bond, giving a detailed account of his late visit to the Observatories of Europe.*

This latter paper is valuable, not merely as a scientific report, presenting a complete view of the peculiar characteristics of the different Observatories of other countries, but it is especially interesting as showing the cordial reception which was given to Mr. Bond by the most eminent men of science in the Old World. The interest manifested in his inquiries and investigations by the enlightened and accomplished astronomers of Great Britain and Europe, and the obliging facilities which they furnished him in executing the commissions intrusted to him, deserve the most grateful acknowledgments from the government of the College.

A number of valuable publications have been made by the institution during the past year; and nothing is suggested by the Director, as wanting to the entire success of the establishment, but the creation of a fund for the payment of its current expenses and printing, which shall relieve the University and the Director from a burden which does not belong to either of them. The Committee cordially concur with the Director in the hope, that public liberality or private munificence may, at no distant day, make permanent and ample provision for this purpose.

The munificent bequest of Edward Bromfield Phillips, one of the largest ever made in this part of the world to the cause of pure science, and which has given fresh lustre to a family name which has so many titles to be held in grateful remembrance by the friends of education and improvement, is understood to be strictly limited to the purchase of books and instruments, and the payment of the salaries of Observers. Even the apartment intended for the reception of the Phillips Library remains unfurnished, for want of funds. It is hoped and believed that such a want can only require to be known in order to be supplied.

---

* Omitted.

By order of the Committee,  
Robert C. Winthrop, *Chairman.*

*Boston*, 21*st January*, 1853.

---

## *Report of the Director to the Visiting Committee of the Observatory of Harvard University.*

1852.

Gentlemen: — As the period has again arrived when it is incumbent upon me to give an account of my stewardship in the supervision and conduct of this Observatory, and to report on the condition of its grounds, buildings, library, and instruments, as well as upon the progress which has been made in astronomical pursuits, it may not be improper for me to offer my congratulations on the prospect of stability in the maintenance and future usefulness which the Observatory at this time enjoys.

During the past year the buildings have undergone no important alterations; their arrangement proves convenient for the intended purposes, and every year's experience adds to the assurance of the excellence of the situation, which, although in the midst of a rapidly increasing neighborhood, is apparently secure from those annoyances so frequently encountered in the vicinity of large cities. The grounds are improving in appearance, and the growth of shrubbery and trees, while it increases the quiet and shelter appropriate to our employment, affords important protection to the instruments from the dust arising from the public thoroughfares. In order to render this protection more complete, I have, during the last season, extended the plantation to the westward as far as the Observatory grounds extend on the Concord Avenue.

In regard to the instruments, we do not perceive that the large equatorial has suffered any diminution of its powers: it continues to give as satisfactory results as in former years. The field of its usefulness has been extended by adapting it to the purpose of differential observations of the smaller stars in zones, and this with a degree of accuracy unsurpassed by meridian instruments. For this improvement, or adaptation of its superior size and quantity of light, we are indebted to Mr. G. P. Bond, who first suggested and then carried the plan into effect. This improvement consists in the introduction of a scale, graduated on a thin plate of mica, into the micrometer of the telescope, at the common focus of the object-glass and eye-lens. The scale was divided by and has all the accuracy of the micrometer screw. The time-record is made by means of the electric process, thus giving positions of stars both in right ascension and declination. It has been found that an arc of a single second of space is confidently ascertained in the declination of a star at a single passage; and the record of right-ascension, being made by means of the galvanic circuit on the cylinder of the spring-governor, has all the accuracy of a meridian-transit observation, so far as the standard stars of the zone may be depended upon. In this manner we have tabulated the positions, magnitudes, and color of two thousand stars.

The transit-circle continues to be used as a transit-instrument, the observations being recorded by the electric method. This method has been recently introduced into the Royal Observatory at Greenwich, and is favorably received by the observers attached to that institution. The Astronomer Royal is busily engaged in completing the necessary arrangements. It is said, that his results thus far obtained are considered by him as indicating that the record of an observation obtained by this method may be relied upon to the accuracy of the twentieth part of a second of time. This independent confirmation of our own deductions, derived from repeated experiments, is very satisfactory.

The azimuth, collimation, and level errors of our transit-instrument have been determined every five or six days during the past year. The results exhibit a very perfect stability of the piers which support the instrument. In July a careful examination was made of the figure of the pivots, together with the deviation of the curve described by the axis of collimation from a great circle. From this trial it appeared that the pivots were sensibly equal, and in a good condition.

The lesser, five-foot equatorial has not yet been remounted in the west dome. Some further advantage might possibly have been derived from its use had we been enabled to complete the dome and column for its reception. However, as we have been so much hindered by sickness during the year, and have had, while able to attend to the duties of the Observatory, such full occupation of our time in other directions, it is not very probable that much more would have been accomplished had this instrument been mounted in its destined place.

The Troughton and Simms forty-two inch transit, having been furnished with a diaphragm of twenty-seven wires, and a pair of tube-levels, has been placed on the piers provided for it in the west transit-room, and has been used in connection with the United States Coast Survey telegraphic operations for the determination of the differences of longitude between this Observatory and the Coast Survey station at Bangor in Maine, and a temporary Observatory which had been prepared near the Government House at Halifax for this purpose, by Captain Shortland, the chief Surveyor of the British government for the coasts and bays of Nova Scotia. The three stations were connected by the Eastern Telegraph line, and the touch of the observer on the break-circuit key at Halifax, at the instant of the passage of a star over the wire of his transit-instrument, was recorded by the armature magnets at each place; and subsequently the passage of the same star was in like manner recorded for Bangor and Cambridge. A single operation of this kind determined the difference of longitude of these points within half a second of time. The extreme length of the wires was estimated at seven hundred and seventy miles.

We have not found it consistent with our other engagements to carry on a systematic series of terrestrial-magnetic observations. The declination and horizontal-force magnetometers remain in nearly the same condition as reported last year. Occasional observations are taken with the magnetic-variation-transit and the "Fox" dip-circle, for the purpose of ascertaining the magnetic declination and inclination. This appeared necessary in order to maintain a general knowledge of the direction of the terrestrial currents, thereby to answer the numerous inquiries which are made on this subject by surveyors and others; but for the nicer purposes of science, such as the determination of the laws governing terrestrial magnetism, it would be vain for us, as at present situated, to attempt more than we have, without being first provided with a self-registering apparatus; and whenever this is done for the magnetic elements, it should be extended so as to include the meteorological instruments relating to atmospheric changes.

Beside the usual meteorological registration at four periods of the day, a series of comparisons has been instituted, extending over several months, of our standard barometer with two other standard barometers, one of them belonging to the Smithsonian Institution, and the other to the Topographical Bureau of the general government. All of these instruments were made by Newman, of London, and have tubes exceeding half an inch interior diameter. They had all been compared previously with the standards of the Royal Society at Somerset House. The opportunity for comparing three such first-class instruments, *directly*, very rarely occurs, and the result has been very satisfactory, inasmuch as it afforded an assurance that our standard barometer had not sensibly changed its normal point, in regard to the English standards, during the ten years that we have had it in use.

Our regular course of astronomical observation has included observations of occultations of stars by the moon, meridian transits of the moon, and moon-culminating stars, transits of catalogue stars, and, occasionally, meridian passages of the planets. The miscellaneous observations embrace Encke's comet at its return; it was first seen at this Observatory on the 13th of January, and was followed to the end of February. The observations have been reduced and published. A series of observations has been made upon the three inner satellites of Saturn, namely, Mimas, Enceladus, and Tethys, and the results of these observations have been combined with those obtained in 1848, and subsequently. In deducing new elements of their orbits, confirmatory observations of the new inner ring of Saturn, and of some remarkable subdivisions of the outer rings, were obtained in the months of December, February, September, and October.

In February, March, and April some new trials were made in daguerreotyping the moon and some of the fixed stars and clusters; but, without more powerful and accurate machinery for driving the telescope of the large equatorial, there is little prospect of improvement upon the impressions heretofore obtained, unless, by some increased susceptibility of the plates, a shorter time may be required for obtaining an impression. The shortest successful exposure of a plate has hitherto been from five to six seconds.

New connections with the telegraph lines have been made the past season. Some of the connections were found to have been unsoldered, probably from the effects of lightning, as strong charges of electricity had been frequently noticed at the Observatory to cause partial explosions during thunder-storms in the vicinity. The "switches" are now more conveniently and safely arranged for a total insulation from the main wires of our local circuit, or for its connection with either the northern or southern branches, or both, or an immediate connection with our ground-plate.

The mean solar time of the Observatory is continued to be transmitted by telegraph to various stations in town and country, on Monday and Thursday of every week.

Zone observations for the positions, &c. of small stars were commenced in April, and have been continued to the present time. There have been a considerable number of observations made regarding the distribution of stars. This has been done with reference to their arrangement into groups. Six hundred fields were compared for this purpose.

The first comet of 1852 was discovered by G. P. Bond, May 18. It afterwards appeared that it had been seen in Europe a few days earlier. We continued to observe upon it while it continued within our reach.

The second comet of 1852 was seen early in July, and has been visible ever since. Our observations upon it have been made whenever the weather has proved favorable, at the proper intervals.

The mass of data collected in connection with the United States Coast Survey Chronometer Expedition, for the purpose of ascertaining the difference of longitude between this Observatory and Greenwich by means of a large number of chronometers transmitted between Boston and Liverpool, in the mail-steamers, is in process of reduction and computation. It is possible that a third season may be required to complete this important work, for which the country will stand indebted chiefly to the energy and foresight of Dr. Bache, the Superintendent of the Coast Survey.

There have been published from this Observatory during the past year the following extracts from our Records: —

1. Article on the Rings of Saturn.
2. Article on a Missing Star.
3. Article on the Three Inner Satellites of Saturn, with Elements of their Orbits.
4. Observations on the First Comet of 1852.
5. An Account of the Solar Eclipse of July 28, 1851, observed at Lilla-Edet, in Sweden, by G. P. Bond.
6. Observations and Elements of Brorsen's Comet.
7. Trial of Mr. Clark's Telescope, experimented upon at the request of the Government of Williams College.

The Phillips Library of the Observatory has received some accessions since my last report. It now contains eight hundred and seventy quarto and octavo volumes, and three hundred and thirty pamphlets, almost exclusively relating to astronomical subjects. We have a fair prospect of collecting around this nucleus a useful astronomical library, as a portion of the Phillips Fund may be annually devoted to this object.

It is thought expedient to publish, as soon as it may conveniently be prepared, a volume to contain the substance of the results of our observations, and the remarks contained in our note-books, properly arranged and discussed, or such portions as may be deemed of general interest and utility. The Corporation of Harvard College has given its sanction to this measure, believing it may now be prosecuted without infringing upon the funds appropriated to the support of the Observatory. Before we can properly consider the Observatory as being fully established, it must be provided with a fund sufficient to defray its current expenses, including its printing. This would relieve both the College and the Director of a burden which does not belong to either. The Phillips Fund is strictly and specially confined by the terms of the bequest to three objects; namely, books, instruments, and the payment of salaries of the Observers. The apartment intended for the reception of the books constituting the Phillips Library remaining unfurnished, is an instance of the necessity of such a provision being made; and many other instances might be adduced in evidence that such a fund is much needed.

As an historical document relating to a very interesting but much-vexed question, I shall append to this report the copy of an official paper * which I have received from Professor A. D. Bache, Superintendent of the United States Coast Survey. It relates to "the progress of improvement and invention in the art of determining longitudes by the electric telegraph." This paper was prepared by Sears C. Walker, Esq., at the request of Professor Bache, from documents on file in the Coast Survey Office at Washington. I have Dr. Bache's permission to publish it.

Subsequently to the last meeting of the Board of Visitors, I received a letter from the Hon. Josiah Quincy, Chairman of the Committee on the Observatory, stating that, in consequence of the then illness of the first Assistant, and the disappointment of the Committee in not being able to receive from him an account of his recent visit to the Astronomical Observatories of Europe, the Committee desired me to furnish such account. The sickness of the first Assistant followed so immediately upon his arrival home, that it became impossible for me to obtain from him all the requisite data for such an account. I was therefore obliged to reply briefly to Mr. Quincy's letter, giving the few particulars which I was at that moment enabled to gather from the letters which Mr. G. P. Bond had written while abroad, with the hope of receiving a more detailed account from Mr. Bond himself, on his recovery. He has since been enabled to draw up a report,† and it is herewith

Respectfully submitted,

W. C. Bond.

*Cambridge, November 17th*, 1852.

To the Hon. Josiah Quincy, Hon. David Sears, Francis Peabody, Esq., J. I. Bowditch, Esq., R. T. Paine, Esq., Hon. William Mitchell, *Committee for Visiting the Observatory.*

---

* Omitted. See page xxiv. &c.

† Omitted.

## XI.

# REPORT OF THE COMMITTEE APPOINTED BY THE OVERSEERS OF THE UNIVERSITY AT CAMBRIDGE TO EXAMINE THE OBSERVATORY, FOR THE ACADEMIC YEAR 1852–53, WITH ACCOMPANYING DOCUMENTS.

BY HON. ROBERT C. WINTHROP,
CHAIRMAN OF THE COMMITTEE.

*Read and Accepted*, 23 *January*, 1854.

THE Committee appointed to visit the Observatory respectfully submit the following Report.

The Committee assembled in the room of the Observer, agreeably to a notice from the President of the University, on the 9th day of November last, and proceeded to the duty assigned to them. Present, Mr. Winthrop, Mr. Quincy, Mr. Sears, Mr. Paine, Mr. Bowditch, and Mr. Borden.

The Committee were happy to find the whole establishment in the most satisfactory condition. The great refractor in the Sears Tower continues to exhibit undiminished power, and to fulfil all the expectations which were formed of it. The west transit-room has been finished during the past year; and a reservoir for the supply of water in case of fire, and for general purposes, has been constructed near the western rooms.

A grant of five hundred dollars, by the Corporation, has been applied to the erection of a cylindrical pillar for the variation-transit, and of a granite tripod for the support of the five-foot equatorial in the west dome, both of which are intended for the accommodation of students. Two sidereal chronometers have been purchased from the Phillips Fund; and a galvanic battery of superior power, promising to be more regular in its operations and more durable than any heretofore in use, has been presented to the institution by the inventor, Mr. Farmer, of Boston.

The Phillips Library has received some valuable additions from foreign Associations and Observatories, and from Professor Bache, of the United States Coast Survey.

The apparatus and arrangements for communicating the time by the telegraphic wires are now so complete, that the beats of the Observatory clock are now practically "heard at every station along the line where there is a receiving-magnet," and that the error of even two tenths of a second is very unlikely to occur. The Observatory time is thus communicated, for the regulation of marine chronometers for the port of Boston, for the arrangements of railroads, and for the general convenience of the people through a large part of New England.

The importance of such a system to the business operations of the community can hardly be over-estimated. The Observer and his Assistants have co-operated during the past year with the conductors of the United States Coast Survey, in observations for determining the difference of longitude between Greenwich and Cambridge, and also with Captain Wilkes, of the United States Navy, in some interesting experiments for ascertaining the velocity of sound under different conditions of atmospheric pressure and temperature. The great refractor has been employed, by the aid of Mr. Whipple, the daguerreotypist, and with partial success, in obtaining photographic delineations of the solar spots.

The report of the distinguished Observer, submitted to the Committee on the occasion of their visit, and which is appended hereto, sets full in detail the astronomical observations and operations of the year. Among these it may be mentioned that the places of hardly less than three thousand stars have been added to the new catalogue of this Observatory, and that important errors have been detected in the places heretofore given of more than three hundred of them. In this process of determining the positions of stars, the electro-magnetic method of recording observations by Mr. Bond's apparatus continues to give results of extraordinary accuracy.

It seems that a catalogue of five thousand stars observed at this institution during the two past years, and forming a complete zone of all stars to the eleventh magnitude inclusive, between the equator and twenty minutes of north declination, is now nearly ready for publication. The Observer states, also, that a large amount of other valuable matter is on hand, which might be prepared immediately for the press. The only want of the institution is an independent fund for defraying the expenses of printing, to which the interest of the Phillips bequest is neither strictly applicable, nor in any degree adequate after its primary purposes have been discharged. The Committee conclude their Report, therefore, with the expression of an earnest hope that this great want of so valuable and flourishing an institution may be at no distant day supplied.

By order of the Committee,

ROBERT C. WINTHROP, *Chairman.*

*Boston*, 23*d January*, 1854.

## *Report of the Director to the Visiting Committee of the Observatory of Harvard University.*

### 1853.

GENTLEMEN: — The principal alterations which have taken place in regard to the buildings of the Observatory during the year past consist in the finishing of the west transit-room, the erection of a cylindrical pillar for the variation-transit instrument, and the raising of a granite tripod-stand for the support of the five-foot equatorial in the west dome. The instruments having been properly mounted, and with the Troughton and Simms transit, which is occasionally transferred from the meridian to the prime-vertical piers, (a separate pair of Y supports having been provided for that purpose, and the local galvanic circuit extended to each of these positions,) they are in a condition for immediate use. A reservoir has also been constructed to the northward of the transit-room, for the purpose of supplying water in case of fire, and for ordinary purposes. The expense of these improvements has been nearly covered by a grant made by the Corporation of Harvard College.

The only change that has been made in the disposition of the grounds has been the closing of the entrance from Concord Avenue, by forming embankments and planting trees next to the road, and making a carriage drive or turn on the eastern side. This has effectually put a stop to what was found to be an increasing inconvenience; namely, the appropriation of this entrance by the public as a common thoroughfare for carriages as well as foot-passengers.

In regard to the condition of the instruments, they will be found, I believe, in good order. No injurious accident has ever occurred to mar the excellence of our great telescope; its powers appear undiminished in the slightest degree. The transit-circle is in the same satisfactory condition as was reported last year; the additional convenience of an observing-chair has been supplied, adding greatly to the comfort of the Observers. In the course of the year two sidereal chronometers have been purchased. These were paid for out of the income of the Phillips Fund.

Our galvanic battery has been removed to the basement of the west wing, the connecting-wires passing from one pole of the battery upward to the five-foot telescope in the west dome; thence descending, they pass between the pillars of the meridian west transit and variation transit; thence to the prime-vertical, and the observing-chair in the great dome; thence to the transit-circle, the spring-governor, and electric clock, returning by the cellar to the other pole of the battery. In the course of the route the wires connect with a set of *switches*, which enable us to form a connection with the Boston and more distant telegraph stations, in such a manner that, by a due arrangement of these switches, the beats of our clock can, in effect, be instantly made audible at any telegraph station within several hundred miles of this Observatory. Thus, by closing the galvanic circuit at 0 seconds of a given minute by the clock, the first beat of the armature magnets that is heard along the line will announce the first second of the given minute; the *hour* is indicated by certain signals. In this way the Observatory time has been communicated, for the regulation of marine chronometers for the port of Boston, for railroad arrangements, and for the occupations of the people generally, through a large portion of New England. This department of our astronomical Observatory is directly useful, and is duly appreciated by that portion of the community which is aware of its existence; and we have the satisfaction of believing that it exercises a beneficial influence on that portion who are ignorant of the source whence the regulation is derived. This method is substantially the same which we adopted in January, 1851.

The plan of communicating the time from an established Observatory, for commercial and other purposes, by the aid of the electric telegraph, has, within the last year, been introduced into England, under the direction of the Astronomer Royal.

The regulation of time has become such an important element in the rapid movements and business operations of the community, that it will not rest satisfied with anything short of the utmost attainable accuracy. Our apparatus is now so complete, that, with ordinary care, the error of half a second in transmitting the time would be very improbable.

The standard barometers, thermometers, and rain-gauges remain unaltered in position or condition. We look forward to the time as not far distant, when the indications of all the meteorological and magnetical instruments shall be self-registered by one uniform time, without the personal attention of an observer oftener than once a day.

Among the astronomical observations of the past year have been those for the determination of the places of stars in certain zones, by the electro-magnetic method of recording the right-ascensions, the declinations having been determined by the differential method alluded to in my last report. It would appear from the results of the past year's trial, that this combination is more accurate and comprehensive than any process heretofore adopted. The extreme nicety of the electric method of recording we have satisfactorily demonstrated by the comparison of a large number of passages of the same star recorded simultaneously by our own apparatus, and by one which we have had constructed on the same principle for the Observatory at Haverford-West, in Pennsylvania; the only difference being in the lengths of their respective pendulums, one making a single vibration in half a second, and the other requiring six tenths of a second. The effect of this difference of a tenth of a second in the times of oscillation was to change continually the relative direction of the motions of the two pendulums in regard to each other, as well as to that of the sidereal clock, which opened and closed the electric circuit at the same moment for both recording cylinders, and to show, as would evidently be the case, *the sum of the errors*, had any such existed, in the motion of the cylinder during the progress of a single second, on the supposition that the spring attachment did not fully answer the intended purpose of equalizing the alternate motion and arrest of the escapement while the rotatory movement of the fly was under the control of the pendulum. The experiment has shown, in the most decisive manner, by the most scrupulous reading of the sheets when taken from the cylinders and compared together, that no discrepancies exceeding one three-hundredth part of a second could be detected, as arising from a defect of this nature. Being thus assured, we can with the greater confidence proceed in the formation of our catalogue.

Up to January 2d, observations on Westphal's comet, additional to those mentioned in my last report, were continued. In November and December we co-operated in some experiments devised and prosecuted by Captain Charles Wilkes, U. S. N., for the determination of the rate at which sound progresses through the atmosphere under different conditions of atmospheric pressure, temperature, direction and force of the wind, and hygrometric state of the air. Signal guns were fired at certain intervals of time, in the grounds adjoining the Observatory, at the United States Arsenal at Watertown, at Fort Independence in Boston harbor, and at the Navy Yard at Charlestown. The times when the reports were heard, and other circumstances, were noted at each of these points, and at the central station in the cupola of the State House, where Captain Wilkes was himself stationed.

In the course of November, December, and January last, very full and careful observations and measurements of the rings and satellites of Saturn were made with the great refractor. Some curious and interesting phenomena of the shadow of the ball and ring were developed. The system of Saturn appears to afford an inexhaustible field for research and discovery. The last five years have proved hardly less productive in interesting developments than any other period since the invention of the telescope.

On March 3d, a new comet was discovered by Assistant Charles W. Tuttle. We however subsequently learned that it had been seen two days earlier at Rome, by Professor Secchi. Mr. Tuttle computed the elements of this comet from his own observations.

In April, a new determination of personal equation was obtained between W. C. Bond, G. P. Bond, and Charles W. Tuttle.

The usual meridian observations, including moon-culminations, have been continued throughout the year, and also occultations of stars by the moon.

A portion of our time has been occupied, in connection with Mr. Whipple, in obtaining photographic delineations by the aid of the great telescope and the five-foot equatorial. In this pursuit a rather unexpected difficulty has presented itself in regard to obtaining definite outlines of the solar spots, owing to the overpowering force or activity of the sun's rays having a constant tendency to overdo the picture. The impressions are only tolerably distinct, not sufficiently so to be of much value.

The places of about three thousand stars, together with several telescopic nebulæ and double stars, have been added to our catalogue. The calculations incident to this work, together with the formation of a *standard catalogue* of comparison-stars, which had to be effected in the greater number of instances by combining results derived from several authorities, were found to require so much labor, that I considered it expedient to employ a special assistant for this work, and I therefore engaged Mr. Runkle, an expert computer, to collate the catalogues derived from foreign observers, and, where discrepancies were noticed, to recompute the places of the stars from the original observations, and reduce the whole to the epoch of our own catalogue. In the progress of this work, more than three hundred important errors in the position of stars, as given in those catalogues, were detected. Some of them have probably been introduced in determining the places of comets, or planets, and consequently may at times have exercised an unfavorable influence over large masses of calculations. I mention this in order to show the utility of such examinations.

The calculation of the results of the Coast Survey Chronometer Expedition of 1851, for the determination of the difference of longitude between Greenwich and this Observatory, has been continued in the care of my first Assistant. The papers are voluminous, and have required additional assistants. The expenses incident to this work have been provided for by the United States Coast Survey.

A galvanic battery of superior power, and which promises, from the short trial we have had of it, to be more uniform in its operations, as well as more durable, than any other heretofore in use by us, has been presented to the Observatory by the inventor, Mr. Farmer of Boston.

The Phillips Library has been increased chiefly by donations from scientific societies and individuals. The Observatories of Greenwich, Cambridge, Oxford, Edinburgh, Markree, Rome, Munich, Vienna, Altona, Hamburg, Pulkova, the Cape of Good Hope, and L'Observatoire Physique Central de Russie, have all very encouragingly sent us their publications. We are also indebted to Professor Bache for a valuable series of seventy-three maps and charts of the Eastern and Western Coasts of the United States. These constitute a complete set of all the Coast Survey maps and sketches published up to the present time.

A catalogue of five thousand stars observed by us in the years 1852-53 is now nearly ready for the press. By a vote of the Corporation of Harvard College, the expense of printing this catalogue has been assumed by that body. It is, nevertheless, extremely desirable that a separate fund should be established for printing the Annals of the Observatory, and that very properly the publication should be issued under its name. The fund should cover expenditures for engraving and incidental expenses. This is now the chief, I might almost say the only, pecuniary want of the Observatory, to render it efficient and permanent. Over and above, we have a large amount of matter which might be prepared immediately for publication. As I considered the meteorological observations would occupy too much space to be printed in the Annals, I have caused them to be copied, from the years 1841 to 1852 inclusive, and to be bound up in a separate volume. The monthly and annual means have been arranged in tables for occasional reference.

Respectfully submitted,

W. C. Bond.

*Cambridge, November* 9, 1853.

To the Hon. Robert C. Winthrop, Hon. Josiah Quincy, Hon. David Sears, Hon. William Mitchell, J. I. Bowditch, Esq., Robert Treat Paine, Esq., Simeon Bordrn, Esq., *Committee for visiting the Observatory.*

---

## XII.

## Report of the Committee appointed by the Overseers of the University at Cambridge, to examine the Observatory, for the Academic Year 1853-54, with Accompanying Documents.

By Hon. ROBERT C. WINTHROP,
CHAIRMAN OF THE COMMITTEE.

*Read and Accepted,* 23 *January,* 1855.

The Committee appointed to visit the Observatory at Cambridge respectfully submit the following Report.

Agreeably to an invitation from the President of the University, the Committee assembled at the rooms of the Director on the 8th day of November last; present, Messrs.

Quincy, Savage, Sparks, Bowditch, Paine, and the Chairman. The Committee proceeded at once to a personal inspection of the various apartments and instruments belonging to the establishment, and were happy to find them generally in excellent condition. The Sears Tower remains still unimpaired by any of the vicissitudes of our changeful climate, and bears constant testimony to the wisdom which laid its foundations so broad and deep.

The great refractor exhibits undiminished power. A new break-circuit electric apparatus has secured still greater promptness and uniformity to the marvellous operations of the electric clock. The only exception to the good repair of the buildings was found in a turning roof, which was originally designed for a temporary purpose, and which now may be conveniently removed altogether.

A part of the grounds having been disfigured during the past year by being suffered to be used as a kitchen garden, the Committee unanimously united in a recommendation that nothing but ornamental shrubbery should be henceforth allowed within the enclosure belonging to the establishment.

After inspecting the premises, the Committee gave attention to the annual report of the Director, which is hereto annexed. From this they learn that considerable inconvenience has been experienced during the past year from the interruptions consequent upon the circuitous route of the telegraph wires by which the Observatory communicates with Boston, — the route being not less than ten miles in length. The Committee trust that the Corporation may be able to concur with the Director in his suggestion, that a direct and independent line should be established at an early day.

The results of the work performed during the past year, as set forth in the report of the Director, are in the highest degree satisfactory. And it is agreeable to find such abundant evidence that, while so few of the Observatories which have been multiplied of late in all parts of the country have exhibited any practical fruits, while in so many other cases the costly instruments have served only as subjects of barren curiosity, and have been left without any systematic superintendence or employment, the Observatory at Cambridge has justified every expectation and every hope of its founders, and has already established a reputation hardly inferior to that of any kindred institution on either continent. At least one great deficiency, however, remains still to be supplied; namely, an adequate provision for a stated periodical publication of its observations and calculations. A great accumulation of valuable matter for the press is on hand, but as yet not a volume has been published. By the liberality of the Corporation, the publication of a single volume has at length been provided for, and the first half of it is already printed. But it is obvious that a permanent publishing fund is necessary for the prosecution of the work. In considering this necessity, the

Committee have been led to inquire into the condition of the endowments of the Observatory. There are two funds exhibited on the Treasurer's books as belonging to the astronomical department. One of them, the Sears Fund, agreeably to the terms of its establishment, is still in process of accumulation, and is not available for the support of the institution. The other, the Phillips Fund, is the principal, if not the sole, present reliance for maintaining the Observatory. But from this fund, amounting to the full sum of $ 100,000, the astronomical department seems to have been allowed only $ 4,917.20 during the past year, and at no time since its establishment has there been paid from it, for the purposes to which it was devoted by the munificent testator, a larger amount than $ 5,000.

It cannot be doubted that during the greater part, if not the whole, of this time, the College have received from this fund an amount equal to a full *six per cent* on the whole sum. But a rule appears to have been adopted by the Corporation to allow only *five per cent* upon any specific fund, and to permit the surplus interest, whatever it may be, to go into the general treasury of the University. Some rule of this sort may, perhaps, have been expedient in reference to small sums held in trust by the College for particular uses, and of which it might involve too much trouble to keep a separate account. But such an idea is hardly applicable to a round sum of a hundred thousand dollars, originally delivered and still held in the best stocks and securities.

It is certainly reasonable that every fund should contribute its share towards the expense of managing the general finances of the College. But it cannot be supposed that the cost of such management can amount to anything like *one per cent* upon the whole endowments. On the contrary, the Committee have every reason to believe, that the College treasury is conducted with a commendable degree of care, economy, and discretion.

Under all circumstances, the Committee are of opinion that a larger sum than $ 4,917.20, or even than $ 5,000, ought to be allowed to the astronomical department from this noble foundation. They cannot acquiesce in the justice of a rule which amounts practically to a diversion of nearly or quite a thousand dollars *per annum* from the purposes exclusively prescribed by the testator, to the general expense account of the University. Nor do they believe that such an example will be encouraging to those who may be inclined to endow particular departments hereafter. It will be obvious to them, that a separate trust will better secure the objects which they may have in view.

It may, perhaps, be a question, how far the income of the Phillips Fund, even were it enlarged to the full measure of its actual yield, would be applicable to the purposes of publication. But while the general wants of the Observatory continue to be as great as they now are, the Committee would feel that they had imperfectly fulfilled the duties assigned them, if they failed to call attention to the rule by which the means for its support are so seriously restricted, and to urge the adoption of a different system.

In conclusion, the Committee have no hesitation in expressing their opinion, that the income of the Phillips Fund annually payable to the support of the Observatory at Cambridge ought to be subject to no deduction except its proportionate part of the *actual* expenses of managing the general funds of the College.

All which is respectfully submitted by

ROBERT C. WINTHROP,
JOSIAH QUINCY,
JAMES SAVAGE,
ABBOTT LAWRENCE,
DAVID SEARS,
ROBERT T. PAINE,
J. INGERSOLL BOWDITCH,
} *Committee.*

*Boston*, 23*d January*, 1855.

## *Report of the Director to the Visiting Committee of the Observatory of Harvard University.*

1854.

GENTLEMEN: — I am not aware that any alteration worthy of remark has taken place in regard to the condition of the buildings or instruments of the Observatory, since my last report to the Committee. The turning domes and the roofs and shutters of the transit-rooms, those sources of frequent trouble in an Observatory, have required of us but slight attention during the year. The revolving roof of the detached building, which was erected in 1844 for the temporary shelter of the five-foot equatorial, is out of repair; and as the cost of a new roof would be considerable, and we are not likely to have any important use for such a building in future, I would recommend that it be removed or broken up. We are now reaping the advantage of our excellent foundations to the piers which support our instruments. Their stability has been put to the severest test, and has afforded the most satisfactory results.

The systematic labors of the Observatory have progressed during the last as in former years, comprising the following observations: — Meridian-transits of stars;

moon-culminations as frequently as circumstances admitted; the occultations of stars by the moon, relying chiefly on the catalogue published quarterly by Mr. Paine, in the Boston Daily Advertiser, for the approximate times, and other circumstances attending their occurrence. These occultations have usually been observed by two, and sometimes by three or four individuals, furnished with telescopes of different dimensions and powers. No instance of the projection of a star upon the disc of the moon has yet been noticed when viewed by the great refractor. This circumstance has contributed to confirm me in an opinion formerly entertained, that the phenomena of the apparent projection of a star upon the disc of the moon at the moment when the star was about disappearing behind or emerging from its border might be rationally accounted for by considering that the radiation varies with the power, condition, and quality of the telescope.

The four comets which have been visible within the last year have received due attention at every favorable opportunity.

The planet Saturn has again occupied a portion of our time. This system continues to excite a great deal of interest. Its situation in the heavens, together with the rare position of the plane of the rings in regard to the earth, will afford us, during the approaching winter season, an uncommonly favorable opportunity for further examination and measurement of the rings, satellites, and body of the planet, and under circumstances very different from those heretofore enjoyed by us since the reception of the large telescope. Our former observations were made when the earth was approaching, and while it was passing through, the plane in which the ring is situated. We shall soon have an opportunity of renewing them when the earth is farthest removed from this latter position.

We had made ample preparation for observing the annular solar eclipse of the sun, on May 26th, but were disappointed from noting the principal phases by the intervention of clouds. Some interesting features of this eclipse were noticed by different observers, five of whom were equipped with chronometers, and telescopes of different kinds, at this Observatory.

In accordance with an arrangement previously made with Dr. Bache, the Superintendent of the Coast Survey, Messrs. G. P. Bond, Charles W. Tuttle, and Richard F. Bond were furnished with telescopes and time-keepers, and prepared to observe the eclipse from the summit of Mount Washington, and in its vicinity, in New Hampshire, at points near the northern limit of the annular phase of the eclipse. The laborious ascent of the mountain proved, however, lost labor, as they encountered a cold rainstorm, which continued throughout the day, effectually preventing any observations.

A new series of zone observations has been instituted, which has already contributed something more than nine hundred stars to our catalogue. A considerable advance has also been made in the re-observation in right ascension, with the transit-circle, of the fundamental catalogue of stars down to those of the ninth magnitude. Observations have also been made with a view of establishing a rule for denoting the comparative brightness of the stars contained in our zones. The subject is one of considerable importance, but presents many difficulties. A new break-circuit apparatus has been devised and applied to the electric clock; this has been found to be more prompt and uniform in its action than anything of the kind heretofore in use.

In the course of the year we have experienced frequent interruptions in our telegraphic communications on the long circuit, by the repeated breaking of the conducting-wires. The line, as at present located, takes a very circuitous course; it runs from the Observatory to Fresh Pond, and then along the Watertown Railroad, till it branches off on the western side of the United States Arsenal in Watertown; then, crossing Charles River, it joins the Worcester Railroad and continues with it to the village of Brighton, thence by the old Cambridge road through Brookline and Roxbury to the Tremont road in Boston, and thence over buildings to State Street. The entire length of the wire must be over a dozen miles, and the long stretch over Charles River can only be made secure by considerable expense. The only permanent and economical remedy for the annoyance complained of would seem to be the construction of a direct line to Boston. Could we have a line of our own directly through Cambridgeport, it would lessen the risk of interruption, as well as the expense of frequent repairs, and at the same time be immediately under our own supervision. The only objection which I am aware of to the adoption of this course would be the separation of the wire at the draw of Cambridge bridge, while vessels are passing through; to meet this, there would, I think, be little difficulty in arranging a self-acting connection at the draw, or a submerged cable. In order to secure this route, it would be necessary to procure an act of incorporation from the Legislature.

During the year some changes have taken place in regard to the assistants at the Observatory. Mr. C. W. Tuttle found himself under the necessity of resigning his connection with the Observatory, in consequence of the failure of his eyesight, a circumstance much to be regretted, as he participated faithfully and ardently in our pursuits, and had proved an eminently capable assistant during the four years of his engagement. A journey to the West, affording relaxation from an undue exertion of his eyes, has so far arrested the progress of the malady as to enable him partially to resume his duties as an assistant, while at the same time he has entered himself as a law student at Dane Hall. In July, Mr. T. H. Safford of the graduating class of this year was engaged as an observer and computer. More recently Mr. Sidney Coolidge has joined the Observatory.

The work of computation since my last report embraces the completion in duplicate of the catalogue of zone stars, as far as Zone 62. The calculations incident to the chronometer expedition of 1851 have been finished. This work of computation was placed in charge of Mr. George P. Bond, and the whole has been conducted under the auspices of the United States Coast Survey. Results have been obtained by this expedition from ninety-two chronometers transmitted in nineteen voyages between Liverpool and Cambridge. The probable error of the concluded longitude of $4^{h.}\ 44^{m.}\ 30^{s.}.66$ by this experiment, is two tenths of a second of time. Arrangements have been made with the Superintendent of the Coast Survey for the prosecution of a third expedition, to embrace every precaution which former experience may suggest for insuring an accurate result.

All our meridian observations, from 1848 to 1854, have been reduced, and are now in process of being copied into blank forms, to be ready for the printer whenever sufficient funds shall be placed at my disposal for that purpose.

In regard to the extra-meridional observations, I would refer the Committee to the annexed schedule of the contents of our equatorial manuscript-books. An examination of this will, I suppose, render it apparent that some steps ought to be taken towards the publication of a selection from their contents, more especially of those bearing date since the year 1847, when the great telescope was first mounted. Some of the more prominent subjects for publication would be the following:—

Saturn, its Ring and Satellites, with numerous diagrams.

Jupiter, its Belts and Transits, Eclipses, and varying brightness of the Satellites; different appearances of the Belts on different occasions. Occultations of the Planet and its Satellites by the Moon, with diagrams.

Mars, measures of its diameter and sketches of its appearance at different times, when near opposition, comparison with neighboring stars, when east and west of the meridian, for the purpose of determining its parallax, with the solar parallax as deduced therefrom.

Neptune, micrometric measures of its disc, and the distance of the Satellite, and the determination of the mass of Neptune, as derived from these measures.

Measures of the Distances of the Satellites of Uranus.

Observations on various Comets, Asteroids, Double Stars, and Nebulæ.

Investigations on the Distribution of Stars, Diagrams of Solar Spots, Description of the Processes adopted in Daguerreotyping Celestial Objects, and the continuation of our Zone-Catalogue of Stars.

In former reports I have, from time to time, alluded to the necessity which then existed — and which still exists — of some provision being made for printing the results of observations. It may conduce to a clearer understanding of the grounds upon which I rest this urgent call upon your attention to this important subject, if I should lay before you my views in regard to the present condition of nearly all the Astronomical Observatories in this country.

We have within the limits of the United States but one example of an Observatory furnished with the means of completing the work for which it was designed, and that one is the National Observatory at Washington. The appropriations for the support of this establishment are on a scale alike creditable to the country and beneficial to science. There provision is made, not only for the support of a corps of about twenty individuals, acting as observers, computers, draughtsmen, or general assistants, but also for the publication of results as soon as they may be prepared for the press. The duties of its officers and assistants, as well as the objects of expenditure which are embraced within the sphere of its activity, are more numerous and diversified than are usually considered as necessarily appertaining to an Astronomical Observatory. There are several private Observatories in this country, which have been erected at the cost of individuals having a taste for astronomical pursuits. Similar establishments in Europe have proved eminently useful, and have made greater contributions in the department of planetary discovery than all the regularly constituted public institutions; but by far the larger number of our American Observatories are attached to colleges or other literary institutions. Buildings more or less appropriate have been erected and furnished with valuable instruments; thus an Observatory is presumed to be established, and the public very naturally are in expectation of discoveries being made. But what are the facts in almost every case? Among all these so-called Observatories, — and they are surprisingly numerous, considering how very recently the subject has engaged public attention, — there are to my knowledge but two instances wherein a permanent, separate provision has been made for enabling the individual in whose charge the instruments are placed to employ them to any useful purpose, much less pursue a connected course of observation, and a discussion and publication of the results. The most usual course of proceeding has been, after the building has been completed and the instruments mounted, to appoint one of the Professors of the College which has had the misfortune to be thus embarrassed, to a general superintendence of the Observatory. The result is certain: he soon finds that the work to be performed is incompatible with his duties as an instructor, already requiring his whole attention; and as soon as the novelty of the acquisition has worn off, the instruments are neglected, or kept only for exhibition, and the whole affair sinks into forgetfulness, or becomes little better than an encumbrance. Whereas if one half of these Observatories had been endowed, for the purposes of observation, with the funds which were expended upon the other half, some profitable results might have been anticipated.

I would not be understood as questioning the beneficial influence which a well-organized and active Observatory exercises upon a community, — far otherwise. I believe such an institution to have a favorable bearing upon the best interests of society, that the tendency of its pursuits is to elevate the mind to a contemplation of the manifold wisdom and power of the Creator, and by a grateful change to relieve the oppressed faculties from the burden incident to the engrossing cares and passions of mere earthly pursuits. I believe that a college or literary institution is an appropriate guardian to such an establishment. What I object to are half-way measures, where no good result can reasonably be expected to ensue; but, on the contrary, much perplexity, mortification, and ultimate loss are sure to be entailed. I appeal to every college that has received the gift of a telescope unaccompanied by the means for its useful employment, whether this be not a fair statement of the case?

At Cambridge, thanks to the prudent forethought of friends! the Observatory is not a burden to the College. We have not only sufficient buildings and excellent instruments, but we have also provision for securing the services of observers and the accumulation of a library. But here we stop, unless some measures be adopted to secure the means of defraying the charge of publishing the results of observations. It should be borne in mind, that the Sears Fund is not at present available; the Phillips Fund is strictly limited, and is barely sufficient for meeting the special objects indicated by the donor, and that printing is not one of them. It is not right to expect that, for this or any other expenditure proper to the Observatory, the general fund of the College should be taxed. However, in accordance with a vote of the Corporation, and our own earnest desire, we have commenced the printing of our first volume of the "Annals." Of this two hundred and fifty pages have already passed through the press. The material for the remaining two hundred and fifty pages, which it is thought will be sufficient to complete the volume, can be furnished as rapidly as the printing can be well executed.

Respectfully submitted,

W. C. BOND.

*Cambridge, November* 8, 1854.

TO THE HON. ROBERT C. WINTHROP, HON. JOSIAH QUINCY, HON. JAMES SAVAGE, HON. ABBOTT LAWRENCE, HON. JARED SPARKS, HON. DAVID SEARS, HON. WILLIAM MITCHELL, R. T. PAINE, ESQ., J. I. BOWDITCH, ESQ., SIMEON BORDEN, ESQ., *Committee for Visiting the Observatory.*

## XIII.

## REPORT OF THE COMMITTEE APPOINTED BY THE OVERSEERS OF THE UNIVERSITY AT CAMBRIDGE, TO EXAMINE THE OBSERVATORY, FOR THE ACADEMIC YEAR 1854–55, WITH ACCOMPANYING DOCUMENTS.

BY HON. ROBERT C. WINTHROP,
CHAIRMAN OF THE COMMITTEE.

---

*Read and Accepted*, 24 *January*, 1856.

---

THE Committee appointed to visit the Observatory at Cambridge have the honor to submit the following Report.

Agreeably to the invitation of the President, the Committee assembled at the rooms of the Director on the 31st of October last, at 11 o'clock, A. M., and proceeded to the duty assigned them. Present, Mr. Winthrop, Mr. Quincy, Mr. Savage, Mr. Sparks, Mr. Paine, and Mr. Borden. The Committee were joined by Mr. Sears, as soon as he had completed his duties as Chairman of the Committee for visiting the Lawrence Scientific School.

The Committee were gratified to find, by inspection, that everything within and around the buildings of the establishment was in good condition, and that all the instruments were in the best working order. They were particularly happy to learn, from the report of the vigilant and faithful Director, that the object-glass of the great refractor had been subjected to a rigorous scrutiny in regard to the apprehended action of the atmosphere upon its surfaces, and that not the slightest indication of incipient efflorescence was perceptible. This fact affords at once the most agreeable evidence of the original excellence of the instrument, and of the careful and judicious management of those who have had the charge of it.

The report of the Director sets forth, also, in detail, the observations and general transactions of the institution during the past year. They embrace particular observations of the solar spots, of seven occultations of stars by the moon, of one immersion and emersion of the planet Uranus, together with forty-two moon-culminations, and between one and two hundred single-wire meridian transits of bright spots or of crater-form cavities situated near the equator on the moon's surface.

Of the new series of zones, commenced on the 7th of September, 1854, forty-two zones, containing about four thousand stars, have been added since the last report, each one of these stars having been twice observed. Some singular phenomena have been disclosed in a renewal of the observations on Saturn, which remain as yet entirely unexplained, and from which some new theories in regard to the character of the rings may, perhaps, be hereafter deduced.

The usual magnetic and meteorological observations have been prosecuted as far as practicable during the year.

A considerable part of the time of the Director and his Assistants, during many months past, has been occupied in co-operating with the United States Coast Survey, in determining the relation of a normal point on this continent to the European Observatories, by a chronometer expedition; and one of the Assistants (Mr. Sidney Coolidge) has voluntarily taken charge of the chronometers belonging to the expedition, and has conducted the necessary transit-observations both at Liverpool and Cambridge. Under his direction and personal care, some fifty chronometers have been transported a distance by sea and land of not less than eighteen thousand miles since the 5th of June last, without any accident sufficient to disturb their rates of going. In this connection, the Director sets forth with a just pride, — which the friends of the University may be allowed to share with him, — that "it may be understood from various papers contained in the Reports of the Superintendent of the Coast Survey, that the longitude of all the principal positions within the United States are dependent upon the longitude of the Harvard Observatory, — other stations being connected with it by means of the electric telegraph, or by triangulation. This, he says, is the natural and rational result of the fact, that the greater number of reliable observations and computations bearing upon this question have been made in this vicinity. Professor Walker, he adds, reports officially, that, independently of the chronometric data, the weight of the Cambridge determinations is in the ratio of 6.4 to 2.5 of any other place in the Union. It was, therefore, taken as the point of departure for the chronometer expedition of the Coast Survey."

The report of the Director suggests a few improvements as necessary for the convenience of the establishment, which the Committee trust may meet with the ready concurrence of the Overseers and Corporation, as they have done with their own. The elevation of the tower upon which the northern mark is fixed, in order to lift it out of the reach of the neighboring trees by which it is becoming gradually obscured, — and the attachment of a plumb-line, properly arranged and loaded, to the southern mark, erected some years ago by Mr. J. J. Dixwell, are particularly specified as of immediate importance.

Your Committee, however, were deeply impressed with the desirableness of another improvement, which the present report of the Director does not allude to. The library of the Observatory is sadly in want of a well-arranged and suitably furnished apartment. There is an excellent vacant room in the building, originally intended for the purpose, but which has never yet been prepared for occupation. The books belonging to the institution are therefore scattered about in different parts of the building, and some of them beyond the reach of those who may require them for consultation. Valuable donations have been received from foreign Observatories and foreign governments during the past year, of which a catalogue is subjoined. Among others, a rare collection of astronomical works, in twenty-six volumes folio, has been received from Prussia. But they find no fit shelves for arrangement and display. Your Committee are unanimously of opinion, that this want ought to be supplied without further delay. And they are of opinion, that such a provision is not only due to the convenience and credit of the institution, but eminently due also to the memory of the youthful benefactor by whose munificent bequest the library was founded, and by whose name it has been called. The other benefactors of the Observatory are already appropriately commemorated within its walls. At the side of the massive *Sears Tower* is fitly inscribed the name of its liberal and enlightened founder, and within reach of the *great refractor* may be seen a tablet bearing the names of all who contributed towards its purchase. But the name of young Phillips is only to be found in the book-marks of a library which has no collected existence. A handsomely appointed apartment, in which all the books of the Observatory should be arranged, and on the walls of which the name of the largest benefactor to the institution should have an honorable and conspicuous place, seems to your Committee to be demanded alike by every consideration of convenience to the living and justice to the dead. Your Committee are unanimously of opinion, that such a provision might reasonably be made out of the interest annually accruing from the Phillips Fund, over and above the sum of five thousand dollars which is allowed to the support of the institution.

The Committee have found peculiar satisfaction in remarking that the Observatory has once more an independent existence as a separate department of the University, with a separate Faculty of its own. During the past year the scientific interests of the College have been called to sustain a severe loss in the death of their distinguished benefactor, the Hon. Abbott Lawrence, whom we cannot but remember was a member of this Committee, and to whom we would pay our passing tribute of affection and respect. It is within the personal knowledge of at least one of your Committee, (the Chairman,) that Mr. Lawrence, had he lived, would have been among the foremost in advocating the adoption of the measure, by which the Observatory has ceased to be classed as a mere branch of the school which so worthily bears his own name.

Your Committee cannot conclude their report, without expressing their high gratification at the progress which has been made in printing and publishing the observations and transactions of this department of the University. The second half of the first volume is already published, and the first half, embracing a preliminary history of the institution, is already far advanced in its preparation. The time has not yet come for doing full justice to the noble endowment by which the expense of these publications has been defrayed, and by which the periodical publication of similar volumes in all time to come has been provided for. We trust that day may be still far distant. We yield to the known wishes of the author of this bounty, by confining our notice of so beautiful a tribute of filial affection to the very words employed by the Director of the Observatory, who concludes his report by saying: "We have been encouraged to proceed in this work by the appropriation of a fund resulting from the will of Josiah Quincy, Jr., out of which fund will also be defrayed the expense of publishing the present and the future Annals of the Observatory of Harvard College."

By order of the Committee,
ROBERT C. WINTHROP, *Chairman.*

*Boston, 24th January*, 1856.

---

## *Report of the Director to the Visiting Committee of the Observatory of Harvard University.*

### 1855.

GENTLEMEN: — The condition of the Observatory in respect to its instrumental equipment is not essentially different from what it was at your last annual inspection. Since that time, however, the great telescope has been again subjected to a rigorous scrutiny in regard to the apprehended action of the atmosphere upon the surfaces of its object-glass. It affords me great satisfaction to be able to state, that, after a most critical examination, not the slightest indication of incipient efflorescence was perceptible; the surfaces, both external and internal, appear as free from any action of this nature, and the polish generally is as perfect, as it was on the day when the telescope was first mounted at Cambridge. This circumstance is the more remarkable, as I have been informed that several object-glasses which were obtained from the same manufacturers, and which have been in use at other Observatories in the United States during nearly the same length of time, have suffered extensive injury from efflorescence, and have consequently required to be reground and polished. The object-glass of our transit-circle shows this kind of growth in a limited degree. I can only suppose that the precaution which was early adopted in regard to the large object-glass, of dismounting it, and separating and cleansing the lenses whenever there appeared to be any indications of moisture gathering on the interior surfaces, (a process which could not be followed with the transit-circle on account of disturbing its adjustments,) has contributed to its preservation. The close proximity of the crown and flint glass when placed in the cell occasions a pretty strong capillary action, which rendered it necessary, at first, to repeat this operation several times; of late years we have had close-fitting caps made, and woollen wrappers, by which it is kept dry when not in use, so that at present the only exposure is during the time of observation, and as the dome answers well the purpose of a dew-cap, there is not much apprehension of any injury arising from this source.

In regard to the equatorial machinery, I have before adverted to the inadequacy of the clock-work to carry the telescope steadily through any considerable arc; it will be advisable, therefore, at some future time, to substitute for the present inefficient machinery, a powerful regulator, to be constructed on the principle of the spring-governor. At present we do not feel the need of the change, on account of our time being so much occupied with zone observations.

Some friends of the Observatory have recently proposed that a second object-glass should be made for the great equatorial, to be kept in reserve in case of accident to the original, and for this purpose a subscription paper has been circulated, and a considerable amount contributed. We cannot but feel grateful to those gentlemen who have thus generously interested themselves in the prospective wants of the Observatory, notwithstanding our consciousness that there are other wants more pressing than that of a duplicate object-glass.

The necessity of having a second electric recording apparatus had become quite apparent during the early progress of the zone observations, for the reason that, as sometimes several observers would be engaged at the same moment at different instruments, separate records were required. It is true that several records might be made upon the same sheet by using distinct batteries and recording magnets, with pens filled with different-colored inks, but this would inevitably produce confusion, and therefore, to supply the deficiency, another machine has been constructed, which is now ready to be put in operation.

The transit-circle has been in such constant use during the year, that it could not at any time be spared for correction of the declination-circle without injurious consequences to the course of observation. This is scarcely regretted, on account of the greater facility, and at least equal accuracy, of the method devised by Mr. George P. Bond for obtaining the declinations of stars through the employment of the great refractor. The transit-circle has been perfectly satisfactory while used as a right-ascension instrument, affording good definition and great steadiness in its corrections. In connection with this instrument, I have to mention that the northern meridian mark is becoming, from year to year, more and more obscured, by the growth of trees upon a hill about a mile to the north of the Observatory. The owner of the trees has been applied to, but he is not yet disposed to render us any relief from this annoyance. The alternative seems to be the elevation of the mark, which may be very securely effected by an addition to the tower upon which the mark is fixed. The whole expense of this alteration would not probably exceed one hundred dollars. The southern mark, erected some years ago by Mr. J. J. Dixwell, at his own expense, continues to be as useful as had been anticipated; the only improvement which I have thought it at all important to suggest in regard to it is, to have a plumb-line attached to its centre, with a pointed conical weight centred over a mark on a stone below, for occasionally testing its stability. But the great distance of the meridian mark from the Observatory, joined to the apparent firmness of the building upon which it is placed, renders any essential displacement extremely improbable.

The five-foot equatorial in the west dome has been used principally by Mr. Sidney Coolidge for observing the solar spots. This object was pursued up to the time when he took charge of the chronometers on the Longitude Expedition of 1855. From that time the observations of the sun were necessarily interrupted, all the rest of the observers being otherwise fully employed. For the same reason, the magnetic observations have been suspended, with the exception of the declination, which is frequently observed with the variation-transit, it being the element which is immediately applicable to useful purposes.

The usual outline of meteorological observation has been attended to, and the mean results deduced, and copies made to January, 1855.

The grounds and buildings have undergone but little change since your last visit. That portion of the grounds which had been temporarily occupied by the Professor of Natural History, as a nursery of forest trees and shrubbery, has been neatly laid out. The Observer's dwelling-house has been repainted and papered. The buildings of the Observatory proper are in good condition. Some additional accommodation will be required for the convenience of computers, and for the new recording apparatus.

Of the new series of zones commenced September 27, 1854, between the parallels of 0° 20′ and 0° 40′ of north declination, forty-two zones have been added since my last report. They were found to contain about four thousand stars, each one of which has been twice observed, and, when added to those before reported, will constitute material sufficient for another volume, and complete the review of the heavens from the equator to 0° 40′ north. A new plan has been adopted for magnitudes, which has given more consistent results than could before be obtained.

The year has not been remarkably productive of astronomical phenomena. Seven occultations of stars by the moon, and one immersion and emersion of the planet Uranus, together with forty-two moon-culminations, and between one and two hundred single-wire meridian transits of bright spots, or of crater-form cavities, situated near the equator on the moon's surface, have been observed. These latter were experimentally observed with the moon's limb, for the purpose of ascertaining the relative value of the two methods when applied to the determination of longitudes. They afforded additional evidence that the bisection of the smaller spots, and the transits of the bright points, can be observed with as great exactness as the transit of a star can be under the most favorable circumstances, and much more accurately than it is possible to observe the passage of the moon's limb. No insuperable difficulty is encountered in making a favorable selection from the numerous objects of this kind on the lunar surface. It is necessary, however, that the different observers should be provided with trustworthy charts of the moon, and for this purpose enlarged crystallotype copies of the daguerreotype representation of the moon which was taken some years since by the aid of the large refractor, would answer perfectly, and might be obtained from Mr. Whipple, and distributed, with a table of reference, among the observers. The electric method of recording is perfectly adapted to the rapid succession of time-records which the observed transits of the moon's limb, with one or more points on its surface, would require.

The re-observation by the transit-circle of the fundamental catalogue of stars from the equator to one degree of north declination has been continued.

The renewal of the observations upon Saturn, alluded to in the last report, has disclosed some singular phenomena, exhibited in the distortion of the ball and its shadow cast upon the ring, which remain entirely unexplained. A number of diagrams illustrating these appearances have been preserved. They were watched from November to the end of March with the greatest interest; a remarkable subdivision of the outer ring was particularly noticed on the 12th of February.

The small companion-stars of Procyon have been again compared with the primary, by micrometric measurement. The star itself deviates from its catalogue place, and some anomalies have been presented by the smaller stars in its neighborhood, which it is desirable should be cleared up.

The Chronometer Expedition carried on under the auspices of the United States Coast Survey, for the purpose of determining the relation of a normal point on this continent to the European Observatories, has occupied a considerable portion of our time. Preparations for this work commenced early in March. The results of the former expeditions, in 1849, 1850, and 1851, had proved satisfactory, and Professor Bache considered the subject to be one of sufficient importance to the interests of the Coast Survey to warrant the requisite expenditure, on the part of government, for the further prosecution of the work. It may be understood from various papers contained in the reports of the Superintendent of the Coast Survey, that the longitudes of all the principal positions within the United States are dependent upon the longitude of Harvard University, other stations being connected with it by means of the electric telegraph, or by triangulation. This is the natural and rational result of the fact, that the greater number of reliable observations and computations bearing upon this question have been made in this vicinity. Professor Walker reports officially, that, independently of the chronometric data, the weight of the Cambridge determinations by eclipses and occultations is in the ratio of 6.4 to 2.5 of any other place in the Union. It was therefore taken as the point of departure for the Chronometer Expedition of the Coast Survey.

During the past summer Mr. Sidney Coolidge has voluntarily taken charge of the chronometers belonging to the expedition, and the making of the requisite transit-observations both at Liverpool and Cambridge; the Liverpool Observatory, which is furnished with excellent instruments, particularly a fine transit of the same dimensions and power as the one at this Observatory, having been kindly placed at our disposal for this purpose. It is a fact worthy of notice, that the fifty chronometers employed on this occasion have been carried, under the charge of Mr. Coolidge, a distance, by sea and land, since the 5th of June, of eighteen thousand miles, without an accident of importance sufficient to disturb their rates of going. The summer's work will furnish the data for between two hundred and fifty and three hundred independent results for the difference of longitude between the Observatories of Liverpool and Cambridge.

The computations of the Chronometer Expeditions of 1849, 1850, and 1851 have been prepared for the press by George P. Bond, and will form a volume of about one hundred and fifty pages, as a portion of the Coast Survey Reports.

The computation of the second series of zone observations, embracing some five thousand stars, has been somewhat advanced, and those of the moon-culminations, completed up to January 1st, 1855, are ready for the printer.

In the course of the year the printing of Part II. of the first volume of four hundred and thirteen pages of the Annals of the Observatory has been finished; it consisted of a catalogue of fundamental stars, and of five thousand five hundred stars down to the eleventh magnitude, with some of the twelfth magnitude, situated between the parallels of 0° and 0° 20′ of north declination, with an Introduction describing the method pur-